CROP PESTS
and
HOW TO FIGHT THEM

A Handbook for Agricultural Extension workers and farmers prepared in collaboration with the Department of Agriculture, Maharashtra State

Price Rs. 2.50

DIRECTORATE OF PUBLICITY, GOVERNMENT OF MAHARASHTRA, BOMBAY

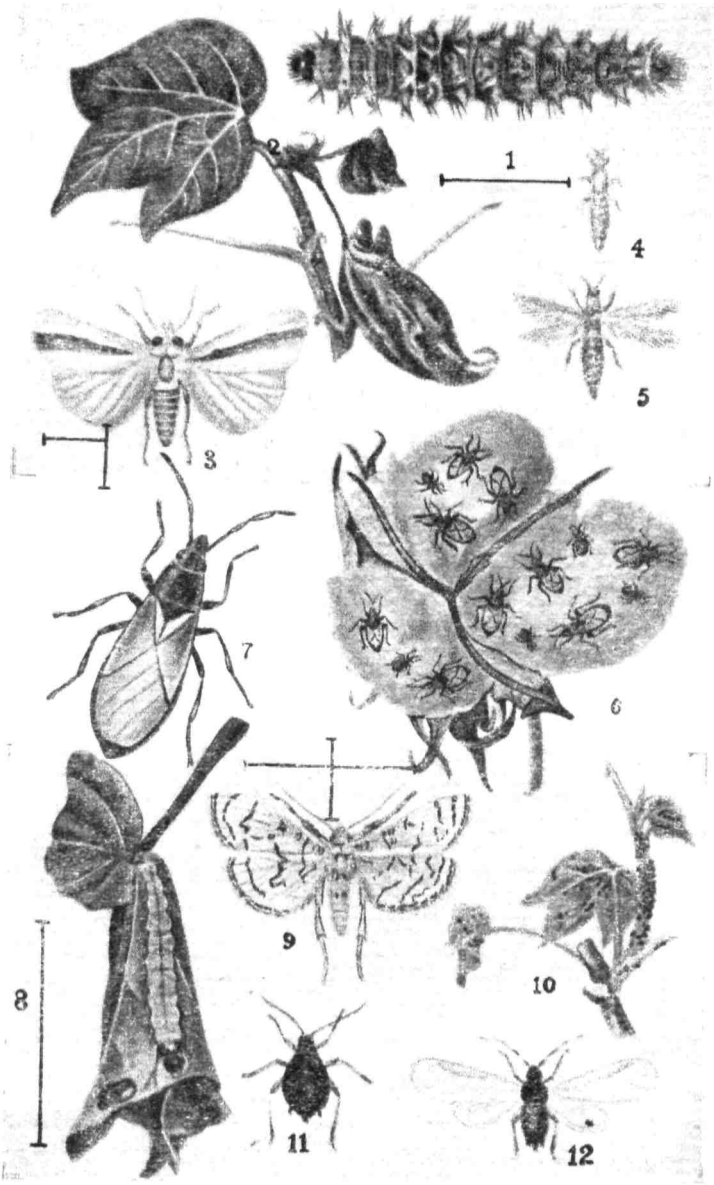

PLATE I

PESTS OF COTTON

SPOTTED BOLL WORM: *1. LARVA; 2 DAMAGED SHOOT; 3 MOTH.*
COTTON THRIPS: *4* NYMPH; *5 ADULT.*

DUSKY COTTON BUG: *6 NYMPHS AND ADULTS ON LINT; 7 ADULT.*

COTTON LEAF ROLLER: *8 CATERPILLAR AND ROLLED UP LEAF; 9 MOTH.*

COTTON APHID: *10 APHIDS ON SHOOT; 11 WINGLESS APHID; 12 WINGED APHID.*

First Published August 1956
Reprinted June 1957
Reprinted September 1960

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FOREWORD

It is a very common experience that when a crop is badly attacked by any insect pest, the farmer gets puzzled and in most cases develops a sense of frustration with an apprehension of calamity for himself, his family and his animals. This is particularly so when the insect attack is severe and widespread, covering not only his own fields but also the fields of several others in the surrounding area. He has no knowledge about the manner in which such insect infestation can be controlled. Even if he might have heard that such control is feasible under the advice and guidance of the local officers of the Department of Agriculture, he either does not know how to go about to obtain the required assistance or he has no resources for taking advantage of such assistance or he may apprehend that any action and expenditure on his part alone may not result in any good for the reason that the insects will continue breeding and increasing in number in the adjacent fields if his neighbours do not take similar action for controlling the pest. This ultimately leads to the development of the philosophical outlook that supports the view that the calamity has been brought about by God's will and hence nothing can or should be done against His will. In consequence, several lakhs of tons of various agricultural crops are lost every year, resulting not only in misery to the farmers as individuals, but also in a great loss of goods of great agricultural value and significance to the nation as a whole. The magnitude of such misery and loss particularly assumes importance when they occur on account of causes which can easily be controlled by methods evolved by the Department of Agriculture as a result of several years of research, experimentation and trial.

At the same time, it is equally true that having regard to the very small business unit of an average farmer and the inevitable limitations to his resources and knowledge, it will not be possible to expect an average farmer to know the remedial measures and to keep with himself the things and equipment required for control of an insect pest immediately after its occurrence is detected. The obvious remedy under these conditions is for the farmers' organisations and co-

operatives to organise and render service for this purpose or for the Department of Agriculture to come forward for assisting effectively the farmers immediately after any serious infestation by insects is reported. Quite a few crop protection co-operative societies have been organised in the various parts of the State, but by far the largest bulk of the crop protection service still continues to be handled by the technical personnel of the State Agricultural Department.

There is not the least doubt that when the farmer is in trouble about insect infestation of his crop, he appreciates—and very effectively—any service rendered to him for getting him out of the trouble. A mention of one of several instances which occurred recently in this connection will, I hope, not be out of place here. During the 1953-54 season, the paddy crop was badly infested by insects in Panchmahals, Surat, Thana, Kolaba, Ratnagiri, etc. The Department of Agriculture received reports about this increasing infestation. Within three days of the receipt of these reports, quite a small army of the departmental personnel adequately equipped with trucks, jeeps, insecticides, dusters and sprayers, attacked the infested paddy fields and brought the trouble under complete control. When the farmers saw this small departmental army working in the fields, they offered—and even insisted on offering—their own services for the work. After the insect trouble was brought under control, they were told that they would have to pay the cost of treatment according to rates prescribed by the Government. Without exception, the farmers paid the full cost on the spot and expressed a sense of deep gratitude for saving their crops from destruction. Quite a few wrote expressing their sense of appreciation of the services rendered.

It is, therefore, obvious that farmers do want the insects appearing on their crops to be destroyed and that they are prepared to pay for the services rendered, provided the treatment is found to be satisfactory and effective. At the same time, it is beyond practical politics for any Government Department in any part of the world so to organise its service as will enable it to render assistance to each and every individual farmer. It is, therefore, essential that every effort should be made to teach the farmer how he himself can control

or at least assist in controlling the insect pest attacking any of his crops.

It is with this object that this small book has been prepared so that the farmer may know how to find out the type or types of insects attacking his different crops, what are the effective remedial measures for controlling the attack, what he should do in case such control is beyond his capacity and what steps he should take whenever he finds that any action taken by him in his own fields will be of no avail or will be of limited utility unless steps are taken by all the other farmers co-operatively or by the Government in treating the fields of all the cultivators with remedial measures.

It will be ideal if all the infested fields belonging to the various farmers are treated on a co-operative basis under the advice and guidance of the technical personnel of the Department of Agriculture. But whenever this is not possible and some cultivators refuse to join the co-operative effort either due to inability or sheer obstinacy or any other cause, it is quite easy for the cultivators to request the Department of Agriculture to treat all the fields by compulsion under the provisions of the Insect Pests and Diseases Act, 1947.

In any case, the most essential point in preventing damage by insect attack is to take remedial measures without any avoidable delay immediately after the attack is located. Any delay will undoubtedly result in permanently damaging the crop, partially or wholly. The first essential consideration for every farmer, therefore, is to find out if any of his crops is attacked by insect pests. The following are some of the points which he should take into consideration :—

(i) If the whole plants are wilting or drying up, indications are that the trouble is due to causes other than insect pests. It may be a disease and in that case, the remedial measures recommended for the insect pests will be of no avail. In such cases, the local Agricultural Assistant or Agricultural Officer or the District Agricultural Officer should be contacted, so that he could give immediate advice and guidance for getting over the trouble.

(ii) After getting satisfied that the trouble is not of the type mentioned under (i) above, one may proceed to find out the insect or insects. They may be on the leaf, either on its upper or lower surface or on both sides, or they may be found inside the stem or stalks or in the roots of the plants or in the fruits or flowers.

(iii) If it is not found possible to identify the insect in accordance with the details given in this publication, the farmer may show the insects along with the damaged plants to the nearest Agricultural Assistant or Agricultural Officer.

(iv) If, on the other hand, the insects correspond strictly to the description and details mentioned in this publication, the remedial measures recommended therein should be immediately adopted.

(v) If it is not found possible either to contact the local Agricultural Assistant or Agricultural Officer personally, or to identify the insects with the details given in this publication, the farmer should collect the insects along with parts of the damaged plants, pack them in a container such as a cigarette tin, taking care to bore holes to the container to facilitate aeration and send the package to the nearest Agricultural Officer or the District Agricultural Officer or even to the Agricultural Entomologist to Government, B.S., Poona, for identification and suggesting remedial measures. If the insect infestation is very serious, the farmer may even ask these officers to visit his fields for personal inspection and advice.

This book serves to indicate the enormous magnitude of the number of species and population of a variety of forms of insect life, as to how the insects feed, either by eating or sucking the underground and upper parts of individual plants. It gives in detail the various types of insects which attack the different types of crops like wheat, jowar, bajri, maize, paddy, the different types of pulses, sugarcane, the different types of fruits and vegetables including potatoes, all oilseed crops, fibre crops, tobacco, stored grain pests, termites, field rats and even wild animals like jackals and pigs. A chapter also deals with locusts which, as everybody knows, literally cause famine if and when they attack a region or a country. For each of

these pests, definite remedial measures, which have been tried and proved successful, have been recommended.

But a word of caution may be recorded in regard to these remedial measures. There is a variety of insecticides sold in markets in the rural areas by all sorts of firms, shops and persons. A particular insecticide designated by a particular name and sold by a number of persons may or may not be equally effective. The stock may be either old or spurious. Every farmer must, therefore, take special care to see that he makes purchases of the recommended insecticides from only such persons or firms who can be depended upon for delivery of goods of specific quality. The local Agricultural Assistants or Agricultural Officers or the District Agricultural Officers of the Department of Agriculture are always most anxious to advise and assist farmers in the matter of procuring the correct type and quality of the insecticide recommended for any particular pest.

May 1, 1955

Poona. —T. G. Shirname

CHAPTER 1

INTRODUCTION TO INSECTS

Perhaps the most familiar aspect about insects is their multitude. How many are they ? A hundred ? A thousand ? A hundred thousand ? Perhaps innumerable. However, by a rough guess it is estimated that there are over 6,00,000 forms or species, as the biologists call them. By far, it is the largest single group of animals, as we know that even mammals to which we belong number a mere 10,000, while the minute unicellular amoeba are only 17,000. Perhaps the number of species matters little and sinks into insignificance when one sees the incalculably large number of individuals of a single species. Take, for example, the desert locust, how many of them are there ? Nobody can tell with any degree of accuracy. Let us guess and consider the population in an average size swarm of say 5 miles square when on the wing moving in a formation 30 ft. deep. Assuming that a cubic foot of space has, say, 10 locusts, this moderate-size swarm will contain nearly 90,00,000 individuals. In one year India had about 50 swarms and the total population of locusts would then run into 45 crores ! Thus, even at a moderate estimate, they easily out-numbered the human beings residing in our country.

It was this enormity of numbers which was responsible for the Indian name *Lac*—100,000—aptly given to an insect now familiar as "lac" insect which secretes shellac ("lakh" in regional languages). Numbers count for survival not only in human beings but also in insects. Their ability to produce large numbers has been responsible for their survival over millions of years. As a result, insects have been the occupants of mother earth several millions of years prior to the appearance of the first human beings, now the so-called dominant species on earth.

Anyway, what are all these myriads of insects for ? Have they any *raison d'être*? Do they serve any useful purpose? Or are they all as destructive as the desert locust which brings only famine and death in years of epidemics ? In nature

there is a continuous cycle of synthesis of complex compounds by plants and their breaking down which is mostly carried out by animals who use them as food. When an area or region is left to itself, on the whole the number of all living things in the region are likely to stay roughly about equal from year to year. There tends to be a balance amongst the plant and animal communities. Such a balance is often spoken of as the "Balance of Nature". By the supply of food to animals, the plants govern the abundance of many animals and, conversely, many animal species help to keep a large number of plant species in check. In this latter role, insects have been particularly conspicuous. Numerous examples can be cited in support ; however, suffice it to point out that insects which are apparently not useful to us are keeping in check cactus of the genus *Opuntia*. Further, in Hawaii it was found that Lantana had become a serious menace to agriculture by becoming a pernicious weed. This was later checked by introducing an insect pest called the Lantana fly. Apart from these conspicuous examples, in nature insects act as a check to the excessive growth of plants in general. At the same time, some parasitic insects help to reduce plant pests which would otherwise wipe out many plant species. In this complex cycle of nature, insects constitute an important cog wheel which helps to regulate the biotic life of an environment.

Insects have the most varied and interesting modes of living. We all know of plant-feeding harmful insects, and at the same time, we are familiar with the beneficial silk worm and the fascinating honey-bee. Amongst the plant-feeders, some feed on leaves like the grasshoppers and army worms, others like the mangohoppers and the aphids suck the sap, while there are the termites feeding underground on any decaying or dead vegetable matter coming across their foraging expeditions. These are some of the more obvious insect activities. Some not so familiar are the insects feeding on other insects, while there are those which are even known to bore underground lead cables and others which are known to live even in petroleum oils. Due to such a variety in their habits, whether one goes into forests, deserts or the sea, insects of some species or other abound and no area on the earth is free

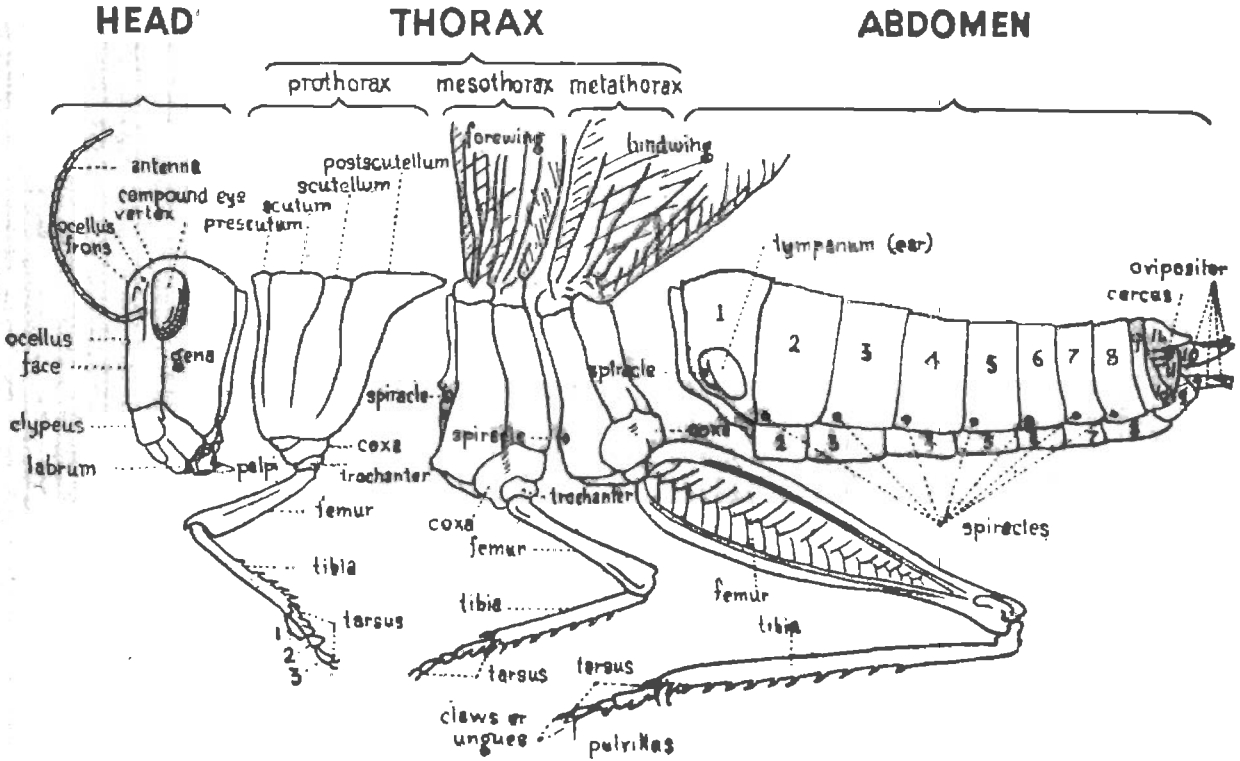


Fig. 1

OUTLINE OF BODY OF A GRASSHOPPER AS SEEN FROM THE SIDE, DISSECTED TO SHOW THE THREE BODY REGIONS AND THE PARTS OF THE BODY COMMONLY REFERRED TO IN BOOKS AND BULLETINS

from them. Indeed, these diverse habits constitute the main foundation of their survival.

What are insects anyway? Are they what in Gujarati are called કીડો, are they: "*Kitak*" in Kannada or are they किडे in Marathi? Perhaps the word insect implies something more specific than either of these and कीटक perhaps is a more suitable word. They are not the same as the endoparasitic worms in children, neither are they the same as ticks on cattle and dogs.

An entomologist would call an animal an insect only if it has certain characters (Fig. 1). To be called an insect an animal should have a chitinous exoskeleton, six jointed legs in the grown-up stage and it may or may not possess wings which when present would be either two or four. When one sees a spider or a milliped, one is inclined to call it an "insect" in the regional language but that is not true. Spiders, scorpions, millipeds, ticks and mites are related to insects but they are all different from them in some respect or another. The main difference is the presence of wings and six legs in insects which have led English-speaking biologists to call them Hexapods—six-legged ones. Further, a typical insect passes through a series of well-defined stages known to every well-informed school boy. These are the egg, the larva, the pupa and the adult insect in the butterfly. The last is a perfect stage which, after having found a mate, will continue the generation once more.

The insects, like all well-developed animals, have a breathing system, but it is substantially different from that of the vertebrates. They have several pairs of openings called spiracles on sides of the thorax and abdomen from which extend respiratory tubes inside the body. These tubes known as tracheae ramify in all tissue cells, directly taking to them the needed oxygen and removing carbon dioxide. They also have a digestive system which enables them to digest proteins, carbohydrates and sugars. Those insects which mainly feed on carbohydrates like the house-fly have greater secretion of carbohydrate-splitting enzymes, while those like the blood-sucking flies which have more proteinous food have correspondingly different enzymes. Thus, considerable variation is

observed in the internal as well as external adaptations of insects suitable to the varied habits which they possess.

Like the higher animals, most insects are either males or females and have separate reproductive systems but they differ from them in this important respect that a great majority of them lay eggs. However, there are a few insects which are hermaphrodites and a considerably larger number which lay young ones. The ability to reproduce is highly developed in the insect species. A large number of moths and butterflies are known to lay hundreds of eggs in the short span of a few days, while there are others whose ability to oviposit may run into several thousand eggs. Not all of these, however, survive for, if by chance they did, they would easily make it impossible for other species to dwell on the earth. Fortunately, many eggs do not hatch and not all of those which hatch complete their life to reach the mature stage as climatic conditions, parasites and predators including birds take a heavy toll of them, permitting only a fraction of the insect population to survive.

Insects, like all living things, do not arise *de novo*. They come from pre-existing ancestors just as the human species does. But on some occasions, their reproduction and survival are not favoured by climatic and other conditions, which cause a great reduction in their numbers. Conversely, when these conditions become optimum, they again build up their population. For example, the desert locust appears in India in regular cycles. The one prior to the present cycle started in 1942 and the present one appeared in 1949; we hope it will disappear in a few years. Similar is the case with the sugarcane grasshopper, the top shoot-borer and a host of other insect species. Thus, most insects become abundant during certain years only. During the period when conditions are unfavourable, all species continue to survive but in small numbers. They are there every year, only we do not see them as their population is sparse. But as soon as proper conditions obtain, there is recrudescence of trouble and the farmer has to guard his crops.

Just as most insects have a way of appearing in large numbers during certain years and not in others, they also

have a seasonal variation in their abundance. Certain species like the Deccan wingless grasshopper are seen only in the Kharif season when green food is plentiful, but not in the drier months. Similarly, the notorious pest, the *Katra* or the Gujarat hairy caterpillar is found in early monsoon but not in winter and summer months when vegetation is sparse. Thus, with the change of seasons, the insects also change their activities so as to suit the time. During periods of suitable weather when plenty of food is available, the insects have their so-called active or feeding stage and then by the time food becomes scarce they attain the inactive or non-feeding stage. So in the case of most species of grasshoppers, nymphs and adults, which are their feeding stages, are abundant in the monsoon, while at the end of that season, they lay eggs in the soil which remain inactive till the next monsoon, thus enabling the pest to survive the prolonged dry period characteristic of the monsoon-fed areas of our country. Similarly, the younger stage of Katra called the caterpillar, which is the damaging stage, is also found in the Kharif season. This stage, after feeding voraciously for a few weeks, enters the pupal stage, which is non-feeding and inactive. In this inactive form, the pest remains in the soil until the next Kharif season, when a moth emerges from it to lay eggs after mating, and thus to start a fresh generation. It is by no means true, however, that all insects have a hibernating stage, which is non-feeding and inactive. For example, the sugarcane top shoot-borer passes winter in the larval stage, when, if the temperature is low, it may stop feeding, only to start developing further as soon as higher temperatures prevail. Again, a pest like the pumpkin beetle hibernates in the adult stage—the feeding stage—remaining inactive, hiding in trash in secluded places on cold days, only to come out on warmer days to feed and cause damage. Thus, in most cases low temperatures reduce the activity of the pests found in the Kharif season. On the other hand, very high temperatures with a dry weather are also unfavourable, leading to high mortality of pests in summer time.

It can thus be seen that what we were taught at school about a butterfly or moth passing through the egg, larval,

pupal and moth stages and thus undergoing metamorphosis, has a great significance in the survival of the species. This type of metamorphosis in a butterfly is called a "complete" metamorphosis (Fig. 2), as the caterpillar, the pupa and the moth are distinctly different and almost unrecognisable as being of the same species. Grasshoppers and bugs, on the other hand, have what is termed an "incomplete" metamorphosis (Fig. 3). Here the insect passes through only three stages—the

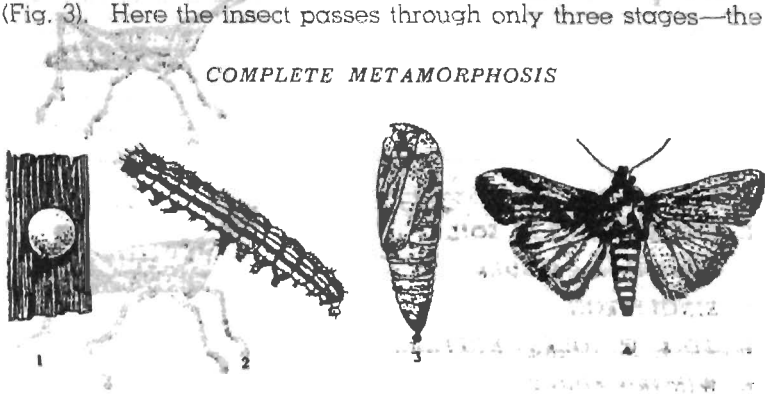
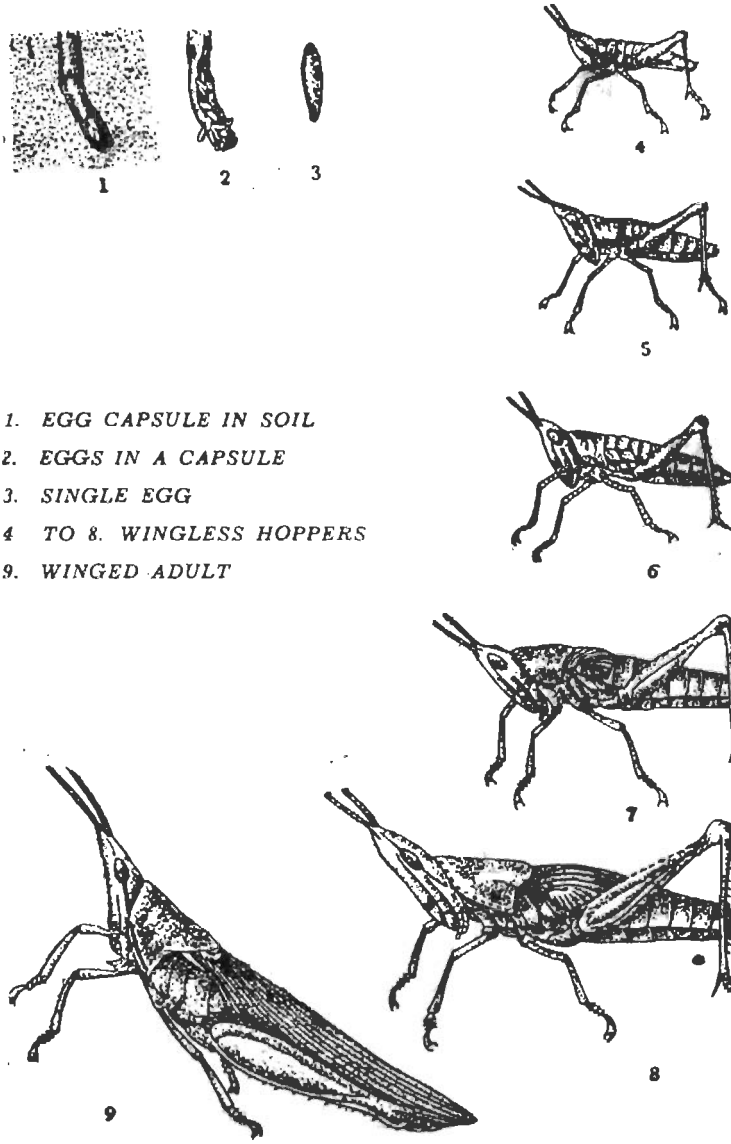


Fig. 2
1. EGG ON LEAF. 2. CATERPILLAR. 3. PUPA. 4 MOTH

egg, the nymphal and the adult. The nymph and the adult are not so much different from each other as the caterpillar or pupa is from a moth. The nymph has the same type of mouth parts known as the chewing type as in the adult which also causes damage. The moth, on the other hand, has a sucking type of mouth parts and rarely causes damage in contrast to its earlier stage (the caterpillar) which has a chewing type of mouth parts which enables it to feed on foliage.

The type of damage an insect causes has great significance in evolving a method for its control. Though numerous types of mouth parts are found in insects, the two most important ones are the chewing type and the sucking type. The former is exemplified by the grasshopper which has a set of appendages in the mouth called mandibles provided with cutting and grinding surfaces by which they cut the leaf and chew it. A quite opposite type of damage is done by bugs, an example of which is the familiar and obnoxious bed bugs and mos-



1. *EGG CAPSULE IN SOIL*
2. *EGGS IN A CAPSULE*
3. *SINGLE EGG*
4 *TO 8. WINGLESS HOPPERS*
9. *WINGED ADULT*

Fig. 3
INCOMPLETE METAMORPHOSIS

quitoes. They are provided with a beak in which long stylets form a suction tube through which they suck blood by the help of a special sucking pump located behind the mouth cavity. The aphid on cabbage and other crops and the cotton jassid have this type of mouth parts which enable them to suck the cell sap from within the plant tissue. When they are present in abundance, they weaken the host, the leaves of which may turn yellow, crumple and wither. Some of those with this type of mouth parts transmit human and plant diseases, amongst which mosquitoes carrying malaria and yellow fever and the tse-tse fly carrying sleeping sickness and the white fly as a carrier of tobacco mosaic and the aphid as a vector of cardimum mosaic are weil known.

The farmer is constantly aware of injurious insects but most people will be astonished if they are told that every pest species has some other species of insects feeding on them and keeping them in check. Any time and everywhere each species has its predators and parasites but for which the pest species will become very numerous. Thus, one of the reasons why insects are not always abundant is that their parasites and predators keep their population down. One of the more commonly known parasites is the Trichogramma, which lays eggs on the eggs of the sugarcane stem-borer, thus destroying many and preventing their excessive reproduction. There is also a lady bird beetle—a predator—which feeds on aphids in large numbers and reduces their intensity as a pest. Many such illustrations can be cited but suffice it to say that all insects are not guilty of harming human effort, as there are a large number which actually help by giving direct benefits to man like honey, silk and lac, and indirect advantage by helping pollination of plants and keeping down the population of pest species.

In this introduction, we have seen what are insects, why they exist, what type of damage they may cause or help they may give, the causes and significance of their seasonal damage and seasonal history, etc.

Such a study of insects is included in the subject of entomology which has its various branches like morphology, study of insect parts, insect taxonomy, study of forms, insect

physiology which treats of the functions of their organs, insect ecology dealing with the relationship of environment and insects, apiculture or bee-keeping, sericulture or silk rearing and, above all, study of insecticides included in insect toxicology. The study of useful and harmful insect species from all angles is included in economic entomology. On all these branches of entomology, there are scores of books all of which no single person can master even in his life-time. It has not, therefore, been possible to give in the succeeding pages even a fraction of the knowledge on the subject of entomology and the reader should know that observations contained in the following pages are a result of research work, needing painstaking observations and experiments over a period of years. The aim of study of entomology is, therefore, not only to dole out mixtures for control of insect pests like a compounder at a dispensary counter, but to investigate various aspects of insect life and arrive at practicable and economical control measures. In doing so, the entomologists owe it to themselves as a part of their social responsibility to make available in a ready-to-understand form all existing information likely to be of practical value to farmers even though for many pests the details have not yet been worked out and are not forthcoming at the moment. It is, therefore, possible that some statements made in this book may yet be unproved or sometimes even not quite correct. At some places, proper control measures are not known. These and other lacunae only time and further research can and must remedy. However, having felt an urgent necessity for a suitable and handy book on this subject, this publication is now being made available, though the technical footing in some cases leaves much to be desired. For the sake of convenience, it was felt necessary to allot work to different persons whose names appear in the relevant chapters, though in most cases they claim no originality for the information compiled by them. Without their willing co-operation, it would not have been possible to complete this work in the short period of a few months.

By G. A. PATEL, B.Sc. (Agri.), Ph.D. (Cornell).

CHAPTER II

THE A B C OF BHC AND DDT

In recent years the popularity of BHC and DDT for plant protection has considerably increased. Along with this, however, there seems to be little evidence of adequate appreciation of the technical knowledge necessary for their use. This chapter has, therefore, been written to acquaint laymen with these insecticides in a more scientific manner. It may, however, be stated that the intention is not to give here the actual uses of DDT and BHC against specific pests. For this information, the reader is referred to subsequent chapters on the control of specific pests. Here the aim is to discuss only the principal facts underlying the use of various formulations of BHC and DDT.

BHC

This was first synthesized in 1825, but its insecticidal properties did not come to be known until 1940-42. The chemical compound, benzene hexachloride (BHC) can exist as different isomers of the same empirical formula $C_6 H_6 Cl_6$. It is also commonly known as 666, representing the 6 atoms of each of the elements contained in the molecule. The different isomers of BHC, called *alpha, beta, gamma, delta* and *epsilon* isomers, do not have the same toxicity to insects. It is the gamma isomer which is most effective as an insecticide and is called lindane, while the other isomers are not only much less toxic to insects but they also give out the usual musty odour associated with crude BHC products. Further, they increase the toxicity of an insecticide to mammals. As the effectiveness of gamma BHC is greater, the toxicity of crude BHC or technical BHC to insects will obviously depend on the amount of gamma isomer in a preparation. Most of the technical BHC now available contain a gamma content of 13 to 14%. Thus, when one talks of 5% BHC dust, it is implied that 5% BHC (which is mixed with 95% parts of inert talc) contains only 0.65% of gamma isomer (on the basis of 13% gamma in technical BHC), while a 10% BHC (13% gamma) powder will have only 1.3% of gamma and the remaining 8.7% are other isomers.

Recently, pure gamma isomer or lindane preparations have also become available. For plant protection these are generally available as 0.65% and 1.3% lindane or gamma BHC without any other isomers. Wettable powders based on pure gamma isomer can also be had. These preparations as they are devoid of other isomers are practically odourless and are consequently much more comfortable for the operators and are less hazardous to mammals. Due to these advantages, pure gamma preparations would always be preferred but for their higher cost when compared to technical BHC formulations. The current price of 5% BHC (crude) dust is about 4 annas per lb., while the equivalent product 0.65% gamma dust sells approximately at 7 annas per lb.

Some of the common formulations of BHC available in the market are :

Dusts

4% BHC
5% ,,
7% ,,
10% ,,
0.65% lindane
1.3% ,,

Wettable Powders

50% BHC water-dispersible powder (to be diluted up to about 0.2% to 0.25% for spray).

25% lindane water-dispersible powder (to be diluted up to about 0.05% to 0.1% gamma BHC for spray).

Emulsion Concentrates (usually for household use)

6% lindane emulsion concentrate (diluted at the rate of 7 ozs. in 20 gallons of water before use).

20% lindane emulsion concentrate (to be diluted before use).

Solution

20% lindane liquid concentrate (to be used for household insects after dilution with kerosene).

DDT

It is popularly though erroneously believed that DDT came to be known as an insecticide during the last World War. The compound was first synthesized in 1874, while its insecticidal properties came to be known only as late as 1936. It was, however, the second World War which stimulated its extensive use, particularly for the control of the louse as a preventive against the epidemics of typhus fever, of which the louse is a vector. Its full potentiality was then realized. The compound chemically known as dichloro diphenyl trichloroethane (DDT) can exist as different isomers. Out of these, the para-para (p-p') isomer is the form whose toxicity is mainly utilised for insect control. Some of the other analogues of DDT have considerable toxicity to insects. For example, a product abbreviated as TDE (1, 1-dichloro-2, 2-bis p-chlorophenyl-ethane) which is almost indistinguishable from DDT, has proved an effective insecticide, though in general it is less effective against most insects than DDT. It has, however, an advantage of being less toxic to warm-blooded animals.

Technical DDT contains from 65 to 80% of p-p' DDT, 15 to 20% of nearly inactive o-p' DDT and 4% TDE. Thus, when one refers to a powder as 5% DDT dust, it does not always mean that all the DDT is of the p-p' type. Reliable firms will, however, certify their products in terms of p-p' DDT. Good technical DDT used for different formulations will have over 75% of p-p' DDT. Thus, a good 50% DDT wettable powder will have about 37 parts or more of p-p' DDT, 13 parts or less of other DDT analogues and the rest inert material with a suitable wetting agent. It is, therefore, very important that one should know these facts while obtaining DDT from the market.

The usual formulations sold in the market are the following:

(1) **Dusting powders**

These are available in the following strengths and are to be used as available :

3% DDT dusting powder
5% DDT ,, ,,
10% DDT ,, ,,
5% DDT/50% sulphur dusting powder for field use.
10% ,, ,, ,, ,, ,, ,, ,,

(ii) **Water-wettable or water-dispersible powders**

50% w/d DDT powder. Generally diluted in the proportion of 1 lb. in 25 gallons of water before use.

(iii) **Emulsion**

Generally sold as a 25% DDT emulsifiable concentrate and mainly used as an indoor spray and is ordinarily not safe for use on plants. For spraying indoors 5% strength obtained by diluting 1 part of the emulsion in 4 parts of water is considered adequate, though a lower concentration may also kill many household insects.

(iv) **Solution in oil**

5% DDT in a light mineral oil. Generally for household use.

Trade names

Each manufacturer gives a trade name for his BHC and DDT products. Thus, Agrocide, Benexide, Gammexane, Hexamer, Hexapur, Hexidol, Hexyclan, Hortex, Klortex, etc. (arranged in the alphabetic order) are some of the names given to BHC preparations, while Autocide, Guesarol, etc., are the trade names of preparations containing DDT. Further each product is given a number denoting a particular concentration of the insecticide or the type of formulation. This number, usually a three-digit figure, has a meaning and is printed after the trade name. Thus, 5% BHC dust is called by various names such as: Benexide 050, Gammexane 025, Hexidol 805, while the water-dispersible (w/d) BHC powder is frequently referred to as Agrocide WD 50, Benexide WP 50, Hexidol 950, Hexyclan DP 50, etc., while 50% w/d DDT powder is sometimes called Guesarol 550. These names are mentioned here so as to emphasize to the reader that when he goes to purchase an insecticide he should know what chemical he desires — BHC or DDT. All Government recommendations are being made as formulations of BHC and DDT

and not by names of trade products.

Comparison of DDT and BHC

DDT and BHC, though chemically different, act in a somewhat similar manner on insects. Both are nerve poisons and cause violent spasms, paralysis and death. Both can get entry into insects either as a stomach or contact poison. In addition, however, BHC can also act as a fumigant. DDT is slower in its action and often 24 hours or more may elapse before death ensues, while BHC has a quick knock-down property. Though the mode of action of these two insecticides is similar, it does not mean that they can always be used interchangeably. For example, BHC is very effective against many species of grasshoppers but DDT is not, while DDT is effective against jassids where BHC gives a poor kill of these insects. The toxicities of these two popular insecticides are so different that it has now become necessary to have formulations containing both BHC and DDT to control different species of insects on the same host. Thus, a w/d powder containing 25% of each and a dust containing 5% BHC, 5%DDT and sulphur in equal amounts are available. Many instances can be cited to show their selective actions, but it will suffice to state that generalizations for their use are possible and for effective control of a particular pest, proper technical advice should be obtained whenever necessary.

Under natural conditions, DDT when exposed does not disappear from the treated surface for a month or so outdoors and for several months indoors. This is because it is insoluble in water, has a low vapour pressure and is resistant to destruction by light and oxidation. In contrast, a surface treated with BHC loses its effectiveness in a short span of a few days. The persistence of DDT over a long period is termed its residual toxicity. This quality is helpful in economising in the number of treatments; as for instance, in the case of indoor treatment like the one for mosquito control, DDT lasts for several months, thus necessitating only a few sprays in the course of a whole year. In the field, its effectiveness is known to last about three weeks or more when used for mangohopper control. The period for which a treatment remains effective

will depend on the nature of the treated surface, rain, temperature, etc.

The persistence of DDT residue has also a disadvantage. In nature, the abundance of a species is quite often dependent on the population of the parasites and predators living on the insect pest The application of DDT for control of a certain species of aphids results in an increase of aphid attack. This is also because DDT does not give a satisfactory kill of many species of aphids but is highly toxic to parasites and predators feeding on aphids. Consequently, the occurrence of heavy aphid and mite population, particularly, the latter, in fields treated with DDT is not infrequent. Hence, when DDT is used, due precautions are necessary. One of the easy ways to prevent subsequent mite population is to add sulphur to DDT preparations.

It may be added that both BHC and DDT have their respective places in plant protection measures, because BHC is more efficacious against certain insects, while DDT controls some others more effectively. In cases where both are useful, DDT is preferred due to its residual effect—provided proper precautions are taken against incidence of subsequent mite infestation. Further, both are toxic to mammals and should not be mixed with food by laymen.

Both BHC and DDT are very injurious to all cucurbit plants like **Kareli,** pumpkins, etc., hence they should not be used for control of pests on them.

Though BHC and DDT have solved many of the serious problems of insect control facing farmers, none of them has proved effective against many pests like stem borers, scale insects, mites, etc. Taking this into consideration along with the fact that a specific pest calls for specific remedies, a layman should not jump to conclusions as to the usefulness or otherwise of any particular insecticide. He should always approach knowledgeable persons for advice, if it is not already available through Government agencies. To follow the advice tendered by others may often result in undue expenditure, to say nothing of suffering crop-losses

By G. A. PATEL.

CHAPTER III

INSECTICIDES, DUSTS OR SPRAYS ?

DDT, BHC and other organic insecticides are generally used as dusts and sprays. These two methods of using dusts and sprays have found widespread use in plant protection work in the field. Besides these methods, insecticides can also be used in the form of poison baits, which find special use in the control of grasshoppers, cutworms, ants, and occasionally, though with doubtful success, in the case of fruit flies. Since DDT and BHC have become popular, many cultivators know that these can be used either as dust or spray. When an insecticide is used either way, it is likely to give control, provided it contains the correct concentration of the insecticide. Further, the insecticides can also be used as poison baits in which a carrier like wheat bran or pulse bran or soaked rice husk can be used mixed with 5% of the insecticide generally. This is broadcast in the field particularly for grasshopper and cutworm control. As the insecticide formulations sold for each of these uses are somewhat different, farmers and even laymen frequently confuse the type of preparation that is to be used for them.

Poison Baits

Some insects have a tendency to come down to the ground surface from their host plants during certain parts of the day. Thus, for example, the grasshopper and locust species can be found loitering on the ground during certain parts of the day. Insects like cutworms remain underground during the day and come out and feed on plants during the night. It is for such insects that poison baits are particularly useful. The baits have an advantage in that the cultivator can easily prepare them. The base used is preferably wheat bran but, if it is costly or not available, pulse husk or rice husk can be used after soaking it in water overnight. For preparing these baits, chemicals such as paris green, BHC and DDT can be used. Paris green is mixed with dry bran to the extent of ¾ lb. in about 14¼ lbs. of bran. This gives about 5% concentrate of insecticide in bait form and will be

adequate for one acre. After mixing it with paris green, the bait may be wetted slightly. After wetting, it should not form sticky balls but bran particles must fall apart when touched.

For BHC and DDT, water dispersible powder sold as 50% BHC wettable and 50% DDT wettable can be used. About 1½ lbs. of either of these materials in 14¼ lbs. of bran will give a bait of about 5% concentration and will be sufficient for an acre. It may be wetted as in the case of paris green. As to whether BHC or DDT should be used, it will depend on the insect and should be ascertained from those who know. For grasshoppers BHC is used and the bait may be broadcast in the morning and for cutworms the BHC bait is used but it should be broadcast in the evening. In making poison baits either of paris green, BHC or DDT, jaggery is usually added to the extent of about ½ lb. in 15 lbs. of bait. In America, instead of wet baits, oil baits have been used. This has, however, not been tried in India.

Dust formulation

When an insecticide is to be used as dust, it is sold in the form of a fine powder mixed with a special quality of talc or some other chemically inactive ingredient in a known proportion. The amount of insecticide is generally 5 to 10%. The mixing of the insecticide with talc is a specialized process and in the absence of efficient mixing and proper selection of the inert material, the efficiency of the insecticide suffers, as a rule. This being the case, it is not advisable for consumers to mix their own dusts and they should use the ready-made powder as sold in the market.

Spray formulation

The other way of using these insecticides is in the form of sprays. Sprays can be of three types: (a) a water suspension spray, (b) an emulsion spray, and (c) a solution spray.

(a) Water suspension spray

The insecticides are also sold as water wettable (w/w) of water dispersible (w/d) powder. This powder usually contains 50% insecticide mixed with some inert ingredient in equal

amounts. To make this mixture water dispersible, chemicals known as wetting and dispersing agents are added, without which a powder will quickly settle in water, resulting in decreased insecticidal efficacy of the spray. A large number of wetting agents are known to chemists, but insecticide manufacturers are generally reluctant to disclose the quality and quantity of wetting agents used by them as it is a part of their trade secret. Unlike the dust formulation, which one has to buy as ready to use powder from the market, the wettable powder can be diluted to any desired concentration and the 50% DDT or BHC water dispersible powder can be used at any desired dilution required for specific pests. Generally, these w/d powders are diluted in the proportion of 1 lb. of 50% DDT or BHC powder in 20 to 25 gallons of water. One lb. of 50% powder in a 20-gallon mixture will give a ready spray containing 0.25% DDT or BHC, as the case may be, while the same quantity diluted in 25 gallons will give a 0.2% ready spray mixture.

(b) Emulsion spray

An emulsion spray is sold in the market as a liquid concentrate containing a known percentage of insecticide. Some of the DDT emulsion concentrates contain 25% DDT, while others less. Each trade product mentions the amount of insecticide in it or states the dilution necessary for its use. The exact composition of each trade product is generally a trade secret, but the usual constituents of an emulsion are (i) the insecticide dissolved in (ii) a mineral oil and (iii) an emulsifier. The last substance helps to give an emulsion in which the insecticide is dispersed in water, giving a milky-white coloured liquid.

Emulsions are generally more toxic to insects than w/d sprays, as the oil that is used in its preparation helps to increase the effect of the insecticide. Thus, weight for weight DDT or BHC in an emulsion is more effective than when used simply as water dispersible powder. For example, it is experienced that a spray containing only 0.5% DDT prepared from an emulsion gives as much mortality of maggots of the housefly as a 3% DDT spray prepared from the water

dispersible powder. This advantage of an emulsion is, however, somewhat offset by the difficulty of manufacturing a good and stable emulsion safe for use on plants. An emulsion when not well prepared has a tendency to "break up" and scorch the plants. Due to this limitation, emulsion sprays have not become popular particularly where a foliage spray has to be resorted to. However, where a dormant spray is to be used, as is the case in temperate climates, an emulsion is used for plant protection. Very few safe emulsions of DDT and BHC exist for plant protection work and hence their use by laymen may be profitably avoided except when a manufacturer guarantees its safety. Its use for household pests like the mosquito and in other places where no plant injury is anticipated is, however, common.

(c) Solution spray

Yet another common method of applying insecticides is as solution spray. DDT and BHC are fairly soluble in common mineral oils. A 5% solution of DDT or BHC in light oil is commonly available for household use. Due to the presence of oils, such solutions are extremely phytotoxic and should be scrupulously avoided as foliage spray. They are mainly meant for mosquitoes, flies and other household insects but can be used on wood work for protection against termites. For full-grown trees with thick stems, application of 5% DDT in oil is safe if applied at the rate of one gallon per 80 trees. However, it should not be used for young grafts, as it is phytotoxic.

Comparison of dusts and sprays

Whether an insecticide is used as a dust or spray, the actual quantity of technical DDT or BHC per acre is nearly the same. For example, when 5% BHC is dusted on an acre, about 20 lbs. of the dust which contains one lb. of technical BHC are required, while 50 to 60 gallons of spray consisting of 0.2% BHC (prepared from 50% water dispersible powder by building 1 lb. in 25 gallons of water) are required per acre. In 50 gallons of this spray used per acre, there is also a total of 1 lb. of BHC. Thus, in either case the theoretical requirement of technical BHC per acre is the same. This being

the case, it is now becoming common to state the control recommendation as a particular amount of technical DDT or BHC per acre, instead of the type of the formulation. In actual practice, however, it has been the experience that a little more technical insecticide is required when used as a spray than as a dust, though this may not be necessary for an equal kill of the insect against which it is being used.

The cost of the insecticide either in the form of spray or dust depends on the size of package. Generally, the cost of the **insecticide** used per acre in either case is nearly the same. However, a pound of technical BHC or DDT when made available in the form of 50% w/d power is much cheaper than a pound of **technical** DDT or BHC made available as dust. An example will make the point clear.

5% BHC dust	**50% BHC w/d powder**
Retail price Rs. 2-8-0 for 10 lbs. To be used as such.	Retail price Rs. 2-4-0 per lb. To be used as a 0.2% spray after diluting 1 lb. in 25 gallons. 60 gallons to be used per acre.
Quantity of 5% powder, 20 lbs. per acre.	Quanty of 50% powder 2.4 lbs. per acre.
Total cost of 20 lbs. of 5% dust for an acre of Rs. 5.	Total cost of 2.4 lbs. of 50% BHC powder used for an acre Rs. 5-6-0.
Quantity of technical BHC in 20 lbs. of dust is 1 lb.	Quantity of technical BHC in 60 gallons of 0.2% spray is 1.2 lbs.
Cost of 1 lb. technical BHC in above is Rs. 5.	Cost of 1.2 lbs. of technical BHC in above is Rs. 5-6-0.
Cost per lb. of technical BHC is about Rs. 5.	Cost per lb. of technical BHC is about Rs. 4-8-0.

Thus, the cost of the insecticide used **per acre** is equal (Rs. 5) either as spray or dust. But actually in the spray the unit cost of technical BHC is thus only Rs. 4-8-0 per lb., which it is Rs. 5 per lb. in the case of 5% BHC dust.

These figures, however, should not be confused with the total cost per acre, as labour charges for spraying and dusting

operations are extra. The spraying operation, though nearly equal in regard to the cost of the material used, requires a far greater amount of labour in terms of man-hours than dusting. In dusting one man alone can treat nearly four acres a day, while for spraying two men, who are generally required, will complete hardly an acre a day. Further, bringing water from a reasonably distant source for spraying will require additional labour; consequently, the spraying operation turns out to be usually costlier than dusting.

One of the chief points to be observed in spraying is that both the upper and the lower surfaces are to be sprayed. This calls for a certain degree of carefulness which is often lacking in untrained operators. Due to the smallness of sprayer tanks and the requirement of a large quantity of the spray, say about 60 gallons per acre, a standard hand-operated sprayer of about 2½ gallon-capacity will have to be refilled nearly 25 times for spraying an acre. Besides, bringing water from a well or other source is also an additional operation. This has a particular significance in Bombay State which has much of its area under dry farming. Even in irrigated crops, when water from irrigation channels is easily available, the fields are usually irrigated and thus inaccessible for the spraying operation, and when the fields are dry the irrigation water is rather far. In addition to being more expensive, the spraying operation is more cumbersome and often results in inefficiency where the operator is inexperienced. This leads to an uneven distribution of the insecticide, untimately resulting in decreased kill. But dust, on the other hand, if of suitable fineness, will distribute itself very evenly with a little care and less labour, and get deposited on all surfaces without difficulty.

However, if spraying is efficiently carried out, it results in an even distribution of the insecticide. Moreover, sprays stick better to plants and have a more lasting effect and may even stand a little rain, while the dust treatment will have to be repeated even after a moderate drizzle.

It has been a common experience that though a cultivator will be initially tempted to have a spray, he will ultimate-

ly abandon it in favour of dust. The spray will, however, claim more interest in the irrigated areas and in regions where excessive breezes during the day restrict the dusting operations to early morning hours. For treating trees when only hand-operated sprayers are available, a dust is far more convenient and is usually preferred. In conclusion, it may be added that dust treatment is cheaper than sprays though, as a rule, local conditions determine which of the two is to be preferred.

By G. A. PATEL

CHAPTER IV

ARE BHC AND DDT HARMFUL ?

After the advent of DDT and BHC, many erroneous ideas about their use and misuse are creeping into the minds of many people. Such mistaken notions may ultimately harm both commerce and agriculture. The two common beliefs are that insects are developing immunity to DDT and BHC, so what is the good of using them ? Moreover, very few people know that the new insecticides are harmful to human beings also.

Resistance of pests to insecticides

One after-effect of the use of organic insecticides, now familiar to many, is the development of resistance in insects after continuous use of the same insecticide. Contrary to popular belief, the existence of insects resistant to the action of insecticides is neither a surprising phenomenon nor a new problem. For example, an HCN-resistant strain of scale insects and the arsenic-resistant variety of the Codling moth in the United States of America have long been known to entomologists. Such strains can be also obtained in the laboratory. For example, while using a fumigant to kill rice weevils, some of them may be made to survive and the survivors can be bred, and when treated with the same fumigant, some weevils may again be made to survive. If this process is repeated on a number of successive generations, one can obtain in the laboratory a strain of the rice weevil which will require a much higher dose of that fumigant than the amount required to get the same mortality in the rice weevil obtaining in nature. In a similar way, it is also possible to breed a strain of the housefly resistant to DDT or any other chlorinated organic insecticide. Constant use of DDT or other products over compact areas will kill the susceptible individuals of the species, leaving behind the resistant ones to breed and increase in number. Repeated treatments will in the end leave only a population not susceptible to the insecticide. This selective process taken place when continuous use is

made of the same or similar insecticides on sufficiently large and compact areas.

It has been observed that resistance to a particular insecticide also results in some resistance to other insecticides of a similar chemical composition, but not to compounds of an altogether different chemical composition. Thus, though DDT-resistant flies do show resistance to chlorinated hydrocarbons akin to DDT, they do not show resistance to pyrethrum. Further, if the resistant group of flies is allowed to interbreed with flies of normal non-resistant population, the whole group will again become susceptible in the course of a few generations. These two facts have led entomologists to believe that if man's effort in the war against such insects is to succeed, a schedule of treatments consisting of two or more dissimilar insecticides may be followed at required intervals. This is expected to obviate the difficulty arising from the development of resistant strains.

In India, the problem of resistant insects has not acquired sufficient importance yet. However, occasionally it has already been experienced that indoor residual sprays of DDT for control of the mosquito, coupled with the use of the same insecticide as a larvicide, has led to the development of resistant strains of mosquitoes in a few years. But at present, no instance of ineffectiveness of DDT or BHC due to insecticide resistance of plant pests in Maharashtra State has been heard of. Nevertheless, a continuous and universal use of organic insecticides in large and compact areas for control of a pest may in future lead to such a problem. But the rapidly advancing science of insect toxicology is fully prepared to meet such a challenge.

Toxicity of DDT and BHC to man

In the absence of proper safeguards, continued use of DDT results in poisonous insecticidal residues remaining on treated fruits and vegetables which ultimately go for human consumption.

It should be known that DDT and BHC even in small amounts are harmful to man and cattle. Not only this, but

when DDT is ingested in sub-lethal quantities, it has a tendency to accumulate in the animal body. The problem of accumulation of DDT in cattle fed on DDT-treated forage crop is also of considerable importance, as DDT is excreted in milk. Effective prevention of such an occurrence is of paramount importance in the case of human beings. Hence, more advanced countries like the U.S.A. prescribe what are known as "tolerance doses" in human food. The permissible quantity of a DDT residue in foods is one part per million (p.p.m.) where all food is contaminated, while in a single food and on apples 5 and 7 p.p.m., respectively, are permitted. Any food having been treated by DDT and possessing more than the prescribed maximum quantity of DDT is objected to by law. The tolerance dose is very small, and anything more than this is hazardous to human health. Therefore, it is necessary to emphasise that vegetables and fruits treated with DDT shortly prior to harvest must be washed properly. Washing by water alone is not effective but an alkaline solution made of 1 lb. of washing soda in 50 gallons of water should be used. A safe procedure is to avoid giving such a treatment immediately before harvesting. In those fruits and fruit products where the rind is not eaten, the chances of insecticide poisoning are certainly less, though it should be remembered that some insecticides may penetrate the fruit.

As regards the toxicity of technical BHC to mammals, it should also be noted that the prescribed tolerance dose in the U.S.A. is the same as DDT (i.e., 1 p.p.m.), while pure gamma BHC being less toxic to mammals is permitted upto 3 to 5 p.p.m. In the case of BHC, however, the problem of insecticide residue in the harvest is less than that in the case of DDT, as it generally disappears in a few days from treated surfaces. This, however, does not imply that it can be mixed with food or any negligence in its use can be tolerated. Further, special care is needed in using a technical BHC product, as it is known to impart a disagreeable odour to potatoes, peas, lettuces, apples and other crops. It has been even found that when some of these crops are grown in soil treated with technical BHC an undesirable odour appears in the harvested crop and sometimes makes them unpalatable.

This difficulty is, however, non-existent in the case of pure gamma preparations.

It is often advocated that DDT and BHC when mixed with foodstuffs like potatoes and grain may be regarded as safe when used for protection against insects. It is, however, felt that such a procedure is not safe and mixing of BHC, DDT or for that matter any of the newly evolved organic insecticides with foodstuffs should be scrupulously avoided. If such practices become common, an immediate necessity for legislation prescribing tolerance doses in marketed foods will become imperative. Meanwhile, proper awareness of the public to this serious health hazard should be developed.

By G. A. PATEL

CHAPTER V

SOME COMMONLY USED PESTICIDES OTHER THAN BHC AND DDT

Usually, insecticides are divided into four categories—stomach poisons, contact poisons, fumigants and systemic insecticides, a new group of insecticides not yet common in India.

A stomach poison, as the name implies, is so used that it can enter the digestive canal of the insect and when it is absorbed in the body, it kills the insect. Such insecticides are usually dusted or sprayed on surfaces of plant parts and when the insect feeds on them, they enter its body and when taken in sufficient amount, it succumbs. Such poisons can also be given in the form of poison baits, wherein a carrier like wheat bran, pulse husk or rice husk—the latter two are not as good as the former in a sufficiently coarse form (but not as powder) is mixed with standard poisons like paris green or BHC to the extent of about 5%; it is then adequately wetted and mixed with a little quantity of an attractant like molasses, and is broadcast on the ground where the insect is likely to roam. When it feeds on it, it proves lethal to it. Due to the nature of its action, such insecticides can only act on insects having the chewing-type of mouth-parts. These include the grasshopper, cutworms, other caterpillars, beetles, etc., but not those with the sucking-type of mouth-parts like aphids, jassids, bugs, etc., which suck the cell sap by pushing their proboscis into the leaf tissue.

The contact poisons enter the insect body through the cuticle or may also clog the breathing apertures or spiracles or enter the respiratory system through it, thus causing toxic symptoms, suffocation and death. These are mainly used for insects with the sucking-type of mouth-parts, which by their very nature, take the cell sap as food after penetrating the proboscis inside the leaf tissue. For this reason, only those insecticides which can penetrate the body wall or interfere with the respiratory mechanism are used. The stomach poisons cannot be used for insects with the sucking-type of

mouth-parts, though contact insecticides can be used for control of insects with the biting-type of mouth-parts if the cost is permissible. For example, BHC, an essentially contact poison, is useful for grasshopper and cutworm control, while arsenates—a stomach poison—cannot be used for aphid or jassid control, as they have the sucking-type of mouth-parts.

Fumigants sold in solid, liquid or gaseous forms, depending on their chemical nature, when exposed to air or suitably treated, release gases deadly to insects. As they act in the gaseous state, it is obvious that they can be used successfully only in closed containers or reasonably air-tight godowns or glass houses, or when the plants or bags are protected by gas-proof covers. In India, they primarily used for fumigation of houses or godowns, grain bins or bags, and for rat and termite control. They are also used sometimes for controlling stem-borers of trees.

Systemic insecticides are those which can be absorbed by the plant through its roots or aerial parts and, on being taken up by sucking insects along with their normal food—the cell sap—they get killed. None of these insecticides is yet widely used in India and hence they are not discussed here.

Stomach Poisons

Some of the commonly used stomach poisons are:—lead arsenate, calcium arsenate, paris green, sodium fluosilicate and cryolite.

Lead arsenate

For use as dust, it is diluted at 1 in 8 parts of finely powdered slaked lime. For spray, 2 lbs. of powder mixed with 100 gallons of water are used.

Precautions:—Avoid treating leafy vegetables shortly before harvest, otherwise wash the parts and treated foliage with water to reduce chances of poisoning man and cattle. Insects against which it can be used are the cutworms, grasshoppers and beetles.

Calcium arsenate

It is more toxic than lead arsenate, as it contains a higher

amount of arsenic. It can be used as dust when diluted with slaked and finely powdered lime, at 1 lb. in 16 parts of lime. It is used against cutworms, grasshoppers and beetles and one must avoid using it on leafy vegetables just before harvesting. If at all used on them, they must be washed thoroughly with water so as to reduce the chances of poisoning man and cattle to a minimum.

Paris green

It contains a considerable amount of soluble arsenic and hence should be avoided for direct dust or spray treatment on foliage and fruits. It can be used for poison baits in the proportion of 2 to 5 lbs. in 100 lbs. of bran with 2½ lbs. of jaggery or molasses.

Sodium fluosilicate

It is a white, odourless, toxic powder. It has a slight scorching effect when dusting is followed by rain. It can be used as dust when diluted with 1 part in 6 to 8 parts of an inert material. Precautions and insects against which it is used are similar to those in the case of lead arsenate and calcium arsenate. This is not commonly used, as it is not readily available. It is, however, weaker than BHC, which has practically replaced the arsenates and the fluosilicates.

Cryolite

This is a mineral which consists of sodium fluoaluminate. It is less dangerous than arsenicals to human beings. As a dust, it may be diluted in 2 to 3 parts of talc and is recommended for use against pumpkin beetles on cucurbits where BHC and DDT are known to cause phytotoxic effects.

Contact Poisons

These are: tobacco decoction, nicotine sulphate, pyre thrum extract, rosin wash, fish oil rosin soap, crude oil emulsion, BHC and DDT.

Tobacco decoction

One pound of tobacco waste (*Dhus*) of a good quality is soaked in 1 gallon of water overnight and subsequently boiled

for an hour. A half lb. of bar soap is, after stirring, dissolved in it and it is diluted in 6 to 8 parts of water and then used. This home-made insecticide, though perhaps a little weaker than other commercial products, is quite useful and can be readily prepared. It is useful for control of soft-bodied insects and is generally used for controlling aphids, thrips and jassids.

Nicotine sulphate

This well-known insecticide is manufactured from tobacco leaf extract and generally contains 40% of nicotine sulphate. For use for aphid control, one part is diluted in 800-1,000 parts (i.e., 1 lb. in 100 gallons) of water and 5 parts of soap are added to it. The addition of soap activities the nicotine sulphate and helps in the release of nicotine which kills the insect. For hardier species of insects like thrips, the dilution is 1 part in 600, with 5 parts of soap.

Lime sulphur

This insecticide came into vogue in the nineteenth century in the U.S.A. for control of San Jose scale. It is also effective against mites, on account of which this compound is still found indispensible in plant protection It is being successfully used against mites causing *tambera* on potatoes and all other cases where they cause damage. Lime sulphur can be easily prepared by laymen but a good ready-made lime sulphur is available in the market. Instead of liquid lime sulphur, a dust mixture of slaked and finely powdered lime mixed with flowers of sulphur in equal proportions is also used. However, liquid lime sulphur should be preferred. The formula is :—

Quick lime	...	...	...	5 lbs.
Sulphur	...	...	...	10 lbs.
Water	...	...	...	5 gallons.

Slake the lime, then add sulphur and make up the mixture to 5 gallons. Boil the mixture for about an hour, keeping the volume constant until it takes on a brick-red colour. Cool and dilute the mixture with 90 parts of water before use. However,

where experienced people handle it. It should strictly be avoided by people who are not familiar with its use.

One comparatively safe method is to use calcium cyanide ($Ca(CN_2)$ which is sold as dust under the name of cyanogas. This compound releases hydrogen cyanide when the moisture of the air acts on it. The gas is slowly released and hence danger to the operator is less. However, constant intake of air contaminated with hydrogen cyanide gas while handling this compound may lead to poisoning. Prolonged work indoors with the dust should, therefore, be avoided. Out of doors, when there is sufficient breeze, it is relatively safe. In all this work, however, a wet handkerchief tied over the nose helps to protect the operator ot a certain extent. The dust is used in large quantities in India for rat and termite control; it is dusted in rat burrows or termite nests by means of a special cyanogas pump. The natural wetness of the burrows is usually enough to release the gas. Details of this [illegible] control elsewhere in this book.

Carbon disulphide

Carbon disulphide (CS_2) is available in liquid form at Rs. 6 per lb. and is used at the rate of 1 lb. in 100 c. ft. of space. The greatest danger while using it is its ready inflammability. Hence its use in large godowns is to be avoided, as chances of causing fires are great. It is, however, convenient for use in small grain-bins and other household containers. After adding the fumigant, the container should be kept closed for at least 48 hours and grain aerated before use. It is not known to affect germination of seeds when used thus.

Ethylene dichloride—carbon tetrachloride mixture (ED/CT)

Like carbon disulphide, this is also available in liquid form; but unlike it, this has no danger of fire. It is used at the rate of 20 to 25 lbs. for 1,000 c. ft. volume with an exposure of 48 hours and is not as dangerous to humans as hydrogen cyanide or methyl bromide (CH_3Br). However, excessive exposure to its fumes should be avoided as it leads to anaesthesia and consequent death. Due to its relative safety, this fumigant has acquired considerable popularity and is at pre-

sent the most commonly used fumigant where laymen have to handle fumigants. Like carbon disulphide, use of this mixture does not affect germination of seeds.

Methyl bromide

Methyl bromide (CH_3Br) is the most potent of fumigants in use in recent times. Unfortunately, it is more dangerous to human beings and is particularly hazardous because it does not have appreciable odour and workmen may enter a fumigated godown without knowing that they are doing so. It leads to immediate toxic symptoms. Consequently, this fumigant should be used only by those familiar with its dangers and a gas mask should always be provided for workers.

For large-scale fumigation, it is sold in gas cylinders under pressure and released in godowns or fumigation covers through a hollow tube and the amount regulated by a stop cock. For small-scale work, it is also available in glass ampoules of a convenient size which can be used for small-size containers wherein they may be broken after the containers are made air-tight. In fumigation work with methyl bromide, it is necessary to have reasonable good air-tight containers, as this fumigant is light and gaseous when released and quickly leaks from any exit.

It is used at the rate of 1 lb. per 1,000 c. ft. of space with an exposure of 12 hours.

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CHAPTER VI

MAJOR PESTS OF SOME CEREALS OTHER THAN PADDY

1. JOWAR

This crop suffers from numerous pests, amongst which the most important ones are the following :

(i) The jowar stem-borer
(ii) Army worms
(iii) The Deccan wingless grasshopper
(iv) The surface grasshopper
(v) The Katra hairy caterpillar of Gujarat
(vi) The jowar stem fly
(vii) The flea beetle
(viii) The aphids (treated under vegetable pests)

I. THE JOWAR STEM-BORER

Marks of identification : The caterpillars are dirty white with many dark spots on the body. A full-grown caterpillars is ¼ to ¾ of an inch

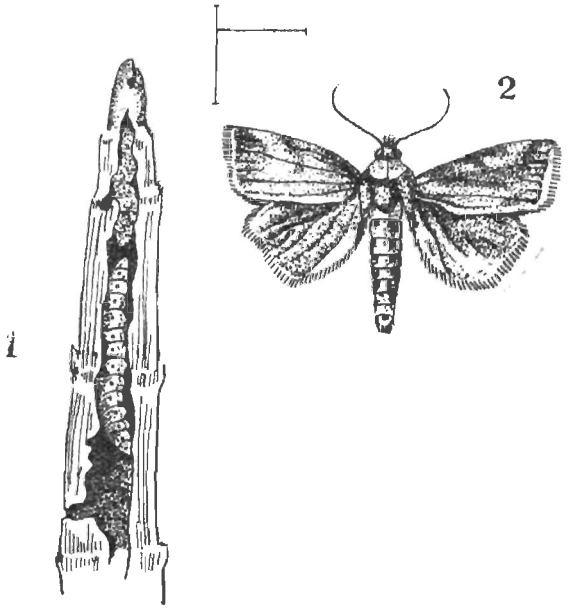

Fig. 4
THE JOWAR STEM-BORER

long with a dark brown head. The caterpillars are found inside the affected stems of plants. Moths are straw-coloured. Their forewings are pale yellowish grey, with minute dots on the apical margin. Their hind wings are white. (Fig. 4).

Host plants: Jowar, maize, sugarcane and sometimes ragi.

Nature of damage: The caterpillar bores inside the stem, thus causing the drying of the central shoots then called "dead hearts". While entering the shoot, the initial feeding of the caterpillar on the whorl gives rise to numerous holes on the leaves which develop later. Drying of the plant often leads to reddening of stems and leaves.

Life history: Creamy white eggs are laid on leaves in clusters which hatch in 6 days. Young caterpillars bore into the stems and kill the central shoots and form dead hearts by eating their internal parts. They live for 3 to 4 weeks and then full-grown caterpillars pupate inside the stems. Moths come out of pupae in 7 to 10 days. The total period of their life cycle is 5 to 6 weeks. The pest hibernates as larvae in the stubbles. The period of activity of the pest is from June to November. There are about four generations in a year. Summer jowar is also frequently found heavily infested with the stem-borer.

Control measures: Being internal feeders, only preventive measures are found practicable and economic. (1) In the early stage of infestation, the stems of plants showing dead hearts should be pulled out along with the caterpillars and they should be destroyed promptly. (2) After the harvest of the crop, the stubbles should be collected and burnt so as to destroy the hibernating larvae. (3) After harvesting the crop, jowar stalks which are used as fodder should be stored in the form of cut fodder. The pieces of cut fodder should measure about half an inch to three-fourths inch bits. Chemical measures have not yet proved effective.

II. ARMY WORMS

Marks of identification : Full-grown caterpillars are 1 inch to 1½ inches long, smooth, stout-bodied, dull greenish coloured with broad light-coloured stripes running along its length on either side of the body. They are found in the central whorl of plants, or may remain under stubbles around the

plants under soil. Moths are of two types. One type of moth is brownish red with prominent spots on the anterior margin of the wings. The hind wings are pale in the middle with dark borders. The other type of moth is dusky brown with a dark median line and less prominent spots on the apical margin of the wings. A pest called swarming caterpillar which is a little darker and with longitudinal bands also is known to infest jowar. Their habits and the control measures for them are identical. (Fig. 5)

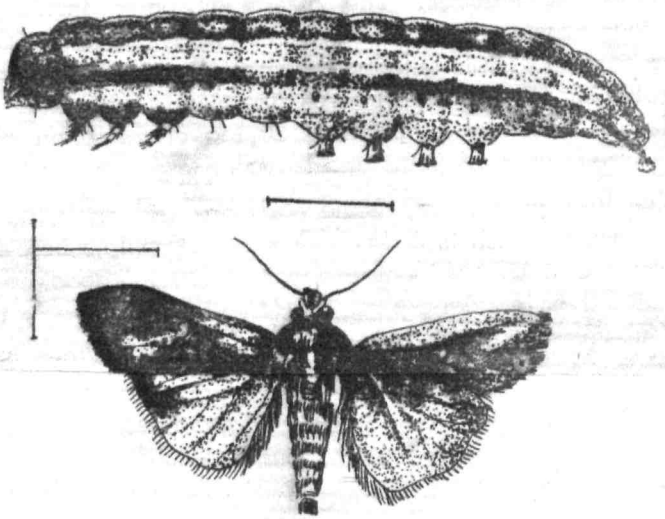

Fig. 5
THE ARMY WORM
(Top) THE CATERPILLAR (Bottom) THE MOTH

Host plants: Jowar, maize, bajri, paddy and other cereals.

Nature of damage: The caterpillars feed on leaves mostly at night while during the day they remain hidden in the whorl or in the clods underground. They migrate from one field to another when their food is exhausted and hence the pest is called "army worms".

Life history: Round, greenish-white eggs are laid on central leaves in two parallel rows in batches which hatch in a week. Caterpillars feed on leaves from the margin inwards and hide in the central whorl of the plant. In bad cases of attack, they completely defoliate the plants as they

have the habit of feeding together. Their larval period is from 21 to 28 days. Full-grown caterpillars descend to the ground for pupation. Their pupal period lasts from 8 to 10 days. The total period of their life cycle is five to six weeks. The pest is active from June to November. Kharif crops suffer more from it than Rabi crops for this reason. There may be a number of generations during a season, after which the insects hibernate in the pupal stage in the soil. The pest does not become abundant every year and it is observed that when a long dry spell follows a good start of monsoon, the pest assumes epidemic form. It shows a tendency to subside if heavy showers occur thereafter.

Control measures : (Preventive) — (1) Collection of egg masses and their destruction. (2) If the attack is localised caterpillars may be collected by employing labour and destroyed. (3) After the harvest of the crop, the infested fields should be ploughed to expose pupae. (Insecticidal)—Insecticidal measures have been found very effective. 5% BHC dust, if properly dusted at the rate of 30 lbs. per acre, successfully controls the pest. Dusting done in the evening—if there is less breeze—is more effective as the pest is a night feeder. If water is easily available, 50% BHC wettable powder may be used as a spray after diluting 1 lb. in 25 gallons of water. About 80 to 100 gallons of spray per acre are needed to control the pest satisfactorily, depending on the size of the crop. 5% BHC poison bait, when broadcasted in the evening, will also control the pest, in case of small-size crops like Nachani if it does not rain, and if the soil is dry.

III. THE DECCAN WINGLESS GRASSHOPPER

Wingless grasshoppers cause widespread damage to cereal crops in the Deccan and the Karnatak. During the last few years, their attack has been serious and has resulted in considerable loss of food crops. These insects are normally found in the fields and it is only under climatic conditions favourable to their development and increase in numbers that they become a serious menace. It is then that the cultivation of jowar crops is greatly hampered and much damage is caused to this crop by this serious insect pest.

Marks of identification : Its nymphs and adults are without wings. The head of the adult is pointed and conical and the body is elongated and

Fig. 6
THE DECCAN WINGLESS GRASSHOPPER (The Female)

greenish to straw coloured, with purple stripes behind the eyes and along the length. (Fig. 6)

Distribution : It is generally met with in Maharashtra and the Karnatak but is not so common in the coastal areas of the State and in Gujarat.

Host plants : Jowar, maize, bajri and pulses.

Nature of damage: The nymphs and adults feed on leaves and in cases of excessive infestation, complete defoliation results.

Life history: The eggs are laid in the soil at a depth of 2 to 3 inches along the bunds and in fields and also in fallow land in batches of 40 to 60 during the period from October to December. These eggs remain dormant in the soil till the following June, when they hatch immediately after the early showers of the monsoon. The young hoppers feed on grasses on the bunds for some time and then move on to the fields and start feeding on the leaves of young cereal crops such as jowar, bajri and maize. The young hoppers develop into adults in about 70 or 80 days after which pairing takes place and egg-laying commences. There is only one generation annually. The pest is active from June to December, and sometimes hoppers from adjoining grasslands migrate to the crop and do serious damage.

Control measures: (Preventive)—(1) Destruction of egg masses when they are laid in the soil by ploughing and harrowing the affected fields especially along the bunds soon after the harvest of the crops, so as to crush and expose them

to the sun, helps to decrease the carry-over of this pest. (2) Destruction of hoppers is also effected by sweeping with bags and running tarred tins over the affected area. Now this is not practised, as the insecticidal method is found economical. (Insecticidal)—Insecticidal measures have been established and used. They are: (1) 10% BHC dust at the rate of 20 lbs. per acre successfully controls the grasshopper. The younger stages may be killed by a lower concentration. (2) Poison baits containing 5% BHC with rice husk or groundnut husk if spread in the infested fields at the rate of 30 to 60 lbs. per acre, can control the pest but dusting is preferable. This bait may be prepared by mixing 10 lbs. of 50% BHC with 100 lbs. of husk soaked in water for about 6 to 8 hours. Dusting of 10% BHC is, however, more convenient and is being used extensively.

IV. THE SURFACE GRASSHOPPER

Marks of identification : The small hoppers are about ¾" long, medium black coloured, with various spots and a rough body surface. (Fig. 7)

Distribution: Generally of importance in Gujarat but may become abundant elsewhere if climatic conditions are favourable.

Host plants : The surface grasshopper is polyphagus and feeds on grasses, jowar, maize, groundnut, cotton, tobacco, niger, etc.

Nature of damage: Nymphs and adults eat leaves and tender shoots of plants.

Life history: In general, it is the same as that of the Deccan wingless grasshopper but it has not been worked out in detail so far.

Control measures: Preventive measures are the same as those for the Deccan wingless grasshopper. Both nymphs and adults are, however, successfully controlled by 5% BHC dust at the rate of 20 lbs. per acre, and 5% poison bait at the rate of 30 to 50 lbs. per acre can also be used, if convenient.

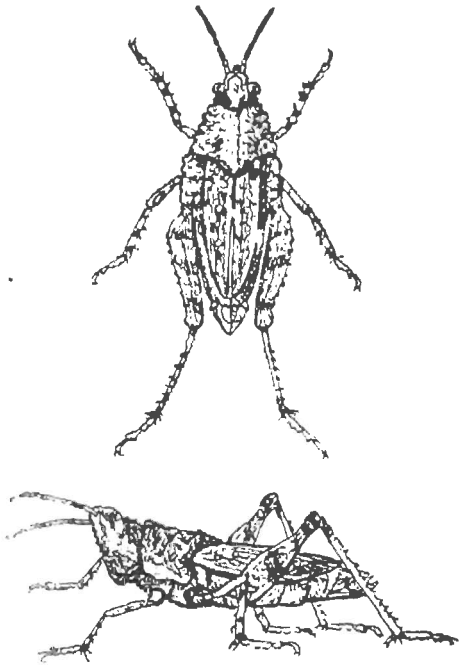

Fig. 7
THE SURFACE GRASSHOPPER

V. THE KATRA HAIRY CATERPILLAR OF GUJARAT

Marks of identification : Full-grown caterpillars are about 1½ inches to 2 inches long, with a thick tuft of brownish hair all over the body. They eat voraciously the leaves of plants during the day time. Moths are of three types. The first type of moth is crimson-bodied with black bands and dots, and its forewings are scarlet-coloured at the front margin. The second type of moth is orange-coloured with black bands and dots and its forewings are white with a red line along the anterior margin, and its hind wings are white with black dots. The third type of moth is yellow-bodied, having a yellow front margin on the forewings. (Fig. 8)

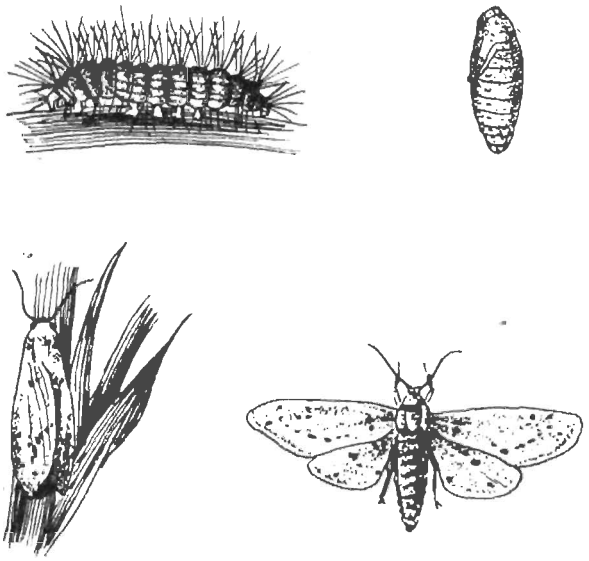

Fig. 8
THE KATRA HAIRY CATERPILLAR
LARVA AND PUPA (Top); THE MOTH (Bottom)

Host plants: It is polyphagus and is known to damage jowar, maize, bajri, pulses, cotton, castor, tobacco, etc

Distribution: It is found mainly in the regions north of the Mahi river in Gujarat.

Nature of damage: The caterpillars feed voraciously on leaves and as the infestation occurs during the early stages of the crop, frequent re-sowing is necessary.

Life history: Soon after the heavy monsoon rains, the moths emerge from hibernating pupae which are in the soil at a depth of about 2 to 3 inches. The females start laying yellowish-white eggs on the undersurface of leaves of weeds or hedge-plants in batches. The main crop is generally not available at this time and hence egg-laying is greater on hedges. The eggs hatch within 3 to 5 days and the caterpillars initially feed voraciously on leaves of hedge-plants. However,

later on when the cultivated crops have germinated, they migrate to the field and become full grown in about 18 to 24 days. Then the descend into the soil for pupation from August and remain in this condition until the next monsoon. After feeding on the crops, the caterpillar develops a tendency to migrate back to the hedge and pupate there in soil and then remain safe from the ploughing operation. The pest is active in the months of July and August and there is generally one generation a year.

Control measures: (Preventive)—(1) In the early stages, collection of egg-masses and young caterpillars and their destruction may be practised. As the pest hibernates in the soil near the hedges, the removal of hedges leads to a corresponding reduction in the seriousness of the pest. This can only be achieved by co-operation among farmers. (Insecticidal)—(1) The infested fields may be dusted with sodium fluosilicate and inert dust mixed in the proportion of 1 to 6 at the rate of 25 to 30 lbs. of the mixture per acre. (2) Poison baits containing 5% BHC or DDT with wheat bran or rice husk or groundnut husk when spread in the infested fields at the rate of 60 to 70 lbs. per acre checks the pest satisfactorily if it is in the migrating stage. (3) On the whole chemical sprays or dusts have not been found satisfactory but 25% DDT emulsion when diluted at the rate of 12½ lbs. in 100 gallons or 2½ lbs. in 20 gallons of water, is known to kill the caterpillars but is costly. Further, this emulsion should not be used on cultivated plants as the plants may suffer due to the emulsion. It may, however, be used on hedges. For crops use of pyrethrum spray diluted at 3 to 5 lbs. in 100 gallons is known to kill the caterpillars, but is again rather costly.

OTHER SPECIES OF THE HAIRY CATERPILLAR

There are numerous species of hairy caterpillars which may become abundant in other parts of the State. Not all of them may be encountered during the monsoon. The chemical control measures recommended for Katra may be profitably adopted for these also.

VI. THE JOWAR STEM FLY

Marks of identification : Its maggots are legless, tapering anteriorly and are found feeding inside the stems of young plants. The adults are flies similar to house-flies, but are very much smaller in size and on their dorsal side, there are a few dark spots.

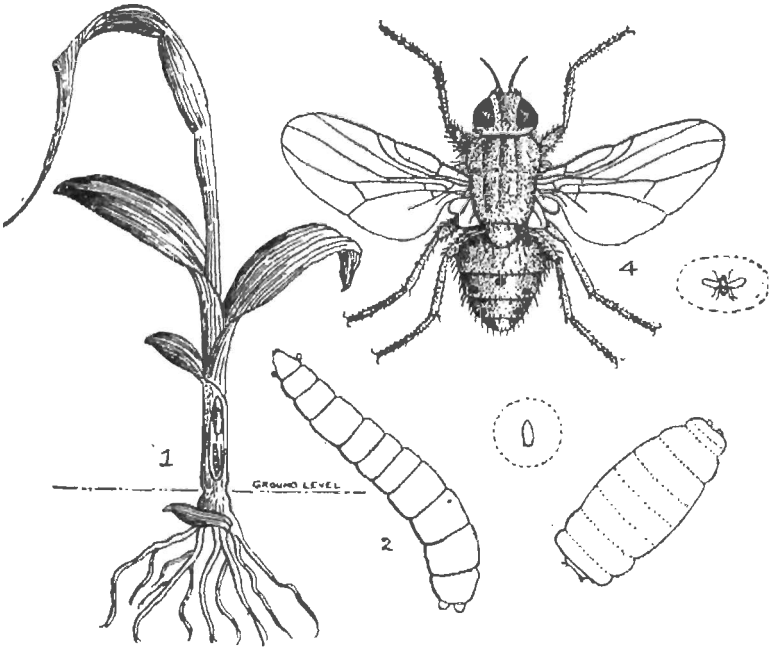

Fig. 9
THE JOWAR STEM FLY
1—ATTACKED JOWAR PLANT; 2, 3, 4, STAGES—LARVA, PUPA AND ADULT

Host plants: Jowar and other millets.

Nature of damage: The maggots bore inside the stem and cause dead hearts and are generally more common in a very young crop.

Life history: The eggs are laid on stems or tender seedlings and they hatch in 2 to 3 days. The maggots bore into the stems of young plants and feed inside the stem for about a week. Full-grown maggots pupate inside the infested stems of plants. The pupal period lasts about a week. The pest is occasionally serious in early stages of the crop.

Control measures: (1) Dead seedlings should be promptly removed and destroyed along with the maggots. (2) The seed rate may be increased to make up the loss. Chemical measures have not yet been established.

VII. THE FLEA BEETLE

Marks of identification : The beetles are blackish and small, about 1/10" long, oblong and with the hind pair of legs thickened by means of which they are able to jump about. Some species may be brownish in colour.

Host plants: Jowar is sometimes seriously damaged in the eastern parts of Maharashtra, though the pest may also occur at other places. A species is also a serious pest of sann hemp.

Nature of damage: The beetles feed generally on the middle part of the leaf-blade and not on the border as is the case with caterpillars and grasshoppers. When the flea beetle feeds on the leaf, there result numerous small holes on its surface.

Life history: Its life history is not known fully but the younger stages, i.e., the grubs, are supposed to be root-feeders.

Control measures: BHC dusting gives a fairly good control and 5% strength may be tried, while 10% BHC will certainly give a very good measure of control.

2. BAJRI

The most important pests of this crop are:

(i) The blister beetle,
(ii) The Deccan wingless grasshopper,
(iii) The surface grasshopper,
(iv) The Katra hairy caterpillar of Gujarat,
(v) Army worms.

I. THE BLISTER BEETLE

Marks of identification : The beetles are black with yellowish-brown stripes across their wings and over an inch long and about half an inch thick. Its other species are smaller, about three-fourths of an inch long and thin, with a light brown or greenish blue colour. All of them have rather a soft body and their wings are also thinner than those of other beetles. The adult insect secretes an acid substance from its body and

when crushed on the human body, it causes a blister and hence its name blister beetle. (Fig. 10)

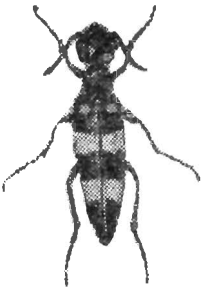

Fig. 10
THE BLISTER BEETLE

Nature of damage: The beetles feed on the pollen and petals of flowers and thus reduce the setting of grains.

Host plants: Bajri, jowar, cucurbits and beans.

Life history: Whitish eggs are laid in the soil in masses which hatch in about a fortnight. The larvae feed on eggs of grasshoppers laid in the soil; thus they are beneficial. They pass through many different stages, which are dissimilar in appearance. The beetles emerge from pupae and remain active from August to December. They eat pollen and thus affect the setting of grains in the earhead. Thus, the adult stage of this pest is the only damaging stage, while its larval stage is beneficial.

Control measures: Preventive measures consist of collection of beetles by means of a hand-net and their destruction. They are also attracted to light, so that light traps may be used but they are not very effective. However, insecticidal measures are more satisfactory. 5% BHC dust is effective against this pest if dusted properly at the rate of 20 lbs. per acre.

3. MAIZE

The main pests affecting this crop are the following:

(i) The pink-borer

(ii) Army worms

(iii) The Deccan wingless grasshopper

(iv) The banded grasshopper
(v) The Katra hairy caterpillar
(vi) The surface grasshopper
(vii) The jowar stem-borer

I. THE PINK-BORER

Marks of identification : *The full-fed caterpillar is about one inch long,* flesh-coloured, smooth with a black head and dark spots on the body. Each dark spot bears a hair. They are found inside the stems of the affected plants. The moths are small and are straw-coloured. Their forewings have a marginal dark line and the hind wings are white.

Host plants: Maize in the dry weather and sometimes wheat in winter.

Nature of damage: The same as the jowar stem-borer.

Life history: Creamy white eggs are laid in clusters inside the leaf sheaths of the stems. The young caterpillars after hatching enter the stem and gradually kill the central shoot of the plant, thus creating dead hearts. If the plants are grown-up, the earheads are also liable to damage. The caterpillars grow about an inch long and pupate inside the stems. The total period from the egg stage to the adult stage is 6 to 7 weeks and this period may be prolonged in the cold weather.

Control measures: The same as those for the jowar stem-borer. (Please see the first part of this chapter.)

IV. THE BANDED GRASSHOPPER

Marks of identification : The adults are yellowish-brown in colour with a dark-brownish patch on the first pair of wings. Both the nymphs and adults eat the leaves of plants. The life history of the banded grasshopper and the control measures for them are the same as those for the surface grasshoppers.

The remaining pests have been discussed under jowar.

4. WHEAT

The main pests which attack this crop are the following:—

(i) The wheat stem-borer
(ii) White ants
(iii) Aphids.

I. THE WHEAT STEM-BORER

The marks of identification and other details are the same as those for the pink-borer of maize.

II. WHITE ANTS

These have been dealt with in detail under termites. (Chapter 18).

III. APHIDS

These have been discussed under the pests of vegetables. (Chapter 10).

By M. V. KADAM and G. A. PATEL.

CHAPTER VII

PESTS OF PADDY AND THEIR CONTROL

Paddy is one of the most important crops of our country but unfortunately this essential foodgrain of millions of our countrymen has been in short supply now for a number of years, resulting in increased necessity of importing rice from Burma and other surplus countries. At a time when the country is making all efforts to increase the yield of paddy by all possible methods, it is of utmost importance that farmers should take adequate precautions to protect their crops from insect pest which take a heavy toll in years of epidemics. Even in normal years, insect pests like grasshoppers, crabs and blue beetles are a serious menace to paddy cultivation. Most of the pests are, however, easy to control if proper and timely action is taken. Certain others need preventive action and unless the cultivator takes it and takes it as soon as the pest appears in small numbers, he will find it next to impossible to check it at a later stage, as effective curative methods are not yet known for some of them. It is for this reason that pests of the crop may be known and, whenever preventive measures are necessary, they should be taken at a very early stage.

I. THE STEM-BORER

Marks of identification : Moths are ½" to ¾" long with a wing expanse of 1½". They are straw-coloured with the forewings yellow and having one black dot on each side. The hind wings are white. The caterpillars are pale, yellowish white and smooth, and are about 1" long when full-grown with the head having orange yellow colour.

Nature of damage: Caterpillars bore into the stems of paddy plants, causing the death of the central shoots. If the infestation takes place later, the shoot bears only empty earheads. The damage caused can be recognised by the whitish appearance of the growing shoots then called dead hearts.

Host plant: Paddy.

Life history: A hundred to two hundred eggs covered with yellowish hairs are laid in clusters many a time on tips of leaves which hatch in about a week's time. On hatching, the caterpillars may first feed on tender leaves for a day or two and then start boring into the stem and become full-grown on feeding inside the stems in 4 to 5 weeks. Then they pupate inside the stems within a transparent silken cocoon. Just before population, the larva makes an exit hole for the future moth to come out. The pupal period is about 8 to 10 days. The pest lingers as caterpillars or pupa in the stubbles left in the field after the harvest of the crop until the next monsoon. It becomes active from June developing further to emerge as a moth and thus start a new generation.

Control measures: Being an internal feeder, only preventive measures are practicable. These include (i) collection and destruction of stubbles after the harvest of crop, (ii) the affected plants showing whitish shoots or dead hearts should be removed and destroyed along with the caterpillars, (iii) egg-clusters which are more common at the tips of leaves of seedlings in the seed-bed may be destroyed by clipping them, while transplanting.

II. THE SWARMING CATERPILLAR

Marks of identification : The moths are ½ to ¾ths of an inch in length, stoutly built, with a wing expanse of 1¼". The forewings are dark brown with a black spot and an irregularly wavy light line near the ends. The hind wings are dusky brown. Full-grown caterpillars measure 1¼" to 1½" long, are dark greenish with a slight yellow tinge; they can readily be distinguished from other caterpillars by the presence of white longitudinal dorsal stripes along their length of body. The head is dark and well chitinished. (Plate II. Figs. 1 to 4)

Nature of damage: Immediately on hatching, the caterpillars feed on grasses or young paddy seedlings. They are active only at night, and during the day they hide in leaf sheaths or leaf whorls or in soil if it is not flooded.

Host plants: Paddy, jowar and other cereals as well as other hosts.

Life history: Two hundred to three hundred eggs covered with greyish hairs are laid in masses. They hatch in 7 to 8 days. The caterpillars on hatching start feeding on leaves mostly at night and become full-grown in about two weeks. Then they pupate in earthen cells generally in soil. The period of their life cycle is 40 to 50 days. They have a habit of migrating and hence they ravish field after field in a short time. More than one generation is found in a season. The pest is known to become abundant when there is a long break in rains after an initial good start.

Control measures: Preventive measures include protection of seed-beds by deep-trenching with steep sides and hand collection of egg masses and their destruction. The caterpillars hide during the day time under clods; so trapping them under planks or small bunches of dry grass may be tried. Dragging a rope across the field may be resorted to after flooding the affected fields so that caterpillars in the leaf sheaths and whorls drop into the water. After the harvest of the crop, the affected fields should be ploughed to expose the pupae.

However, the pest can also be successfully controlled by dusting 5% BHC at the rate of 20 to 30 lbs. per acre. The dusting if done in the evening will give better control as the caterpillars come out to feed at night. Where rains are frequent, spraying BHC water-dispersible powder by diluting 5 lbs. of 50% BHC in 100 gallons of water can be tried. Sixty to 100 gallons of spray per acre should be used for effective control.

III. THE PADDY GRASSHOPPER

Marks of identification : The adults are medium-sized and uniformly greenish without spots, with the hind tibia coloured blue. Immediately behind the head on the prothorax, the presence of 2 to 3 dark black streaks readily distinguishes this grasshopper from the other species. The nymphs when small may be only about ½" and brownish but turn greenish as they grow in size and get older. The male grasshopper is smaller, about 1" long, while the female is longer, about 1½" to 2". A longer variety of the same species is also found in the sugarcane belt known as the sugarcane grasshopper, the males and females of which are 1½" and 2" to

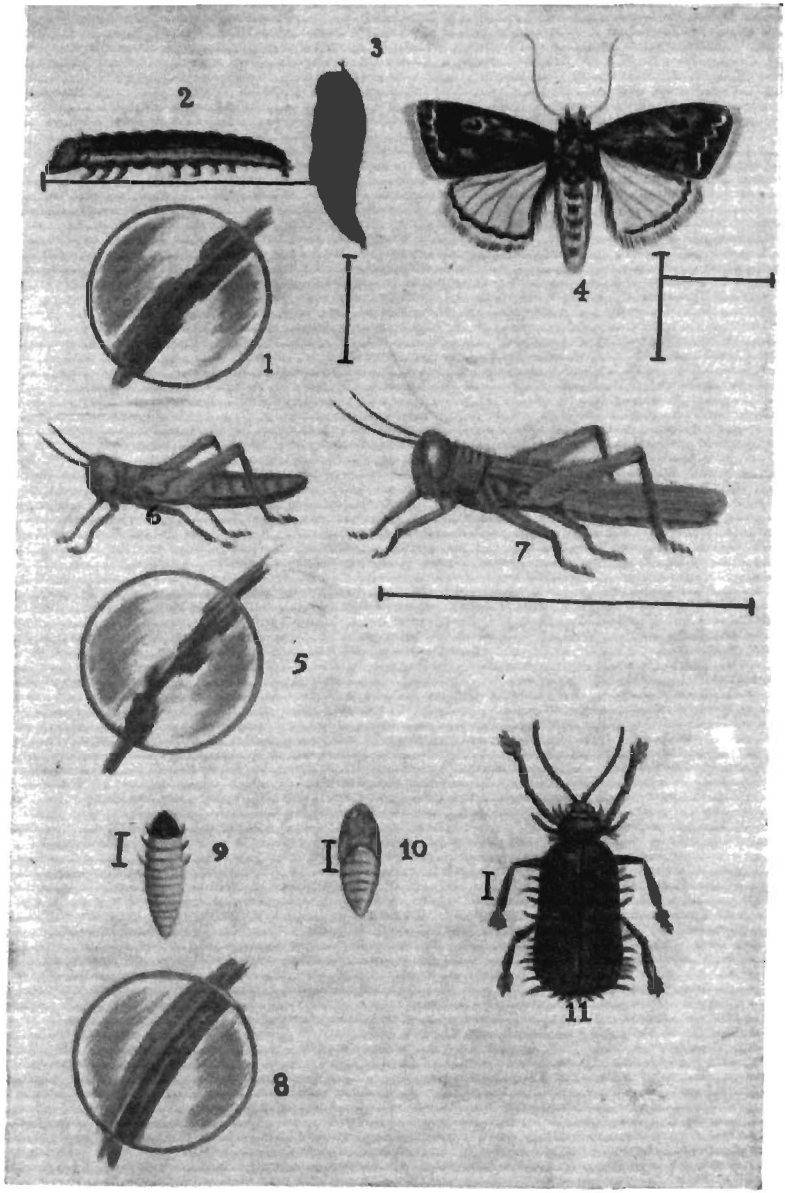

PLATE II

PESTS OF PADDY

SWARMING CATERPILLAR: *1 DAMAGED LEAF; 2 CATERPILLAR; 3 PUPA; 4 MOTH.*

PADDY GRASSHOPPER: *5 DAMAGED LEAF; 6 NYMPH OR HOPPER; 7 WINGED GRASSHOPPER.*

RICE HISPA: *8 DAMAGED LEAF; 9 GRUB; 10 PUPA; 11 ADULT BEETLE.*

Fig. 11
THE RICE GRASSHOPPER

2½" long, respectively. A related species of grasshoppers known as **Phadka** in Rajasthan occasionally becomes abundant in the Gujarat districts. Its life history and control measures are essentially the same. (Plate II, Figs. 5 to 7).

Nature of damage: Both nymphs and adults eat the foliage of plants and also feed on the developing earheads of paddy and other crops.

Host plants: Paddy, sugarcane and grasses.

Life history: The eggs are laid in batches of 30 to 40 or more inside the soil, especially along the sides of bunds and other uncultivated areas. These egg masses remain in the soil during the hibernating stage till the next monsoon. After the first showers of rain in June or July of the following year, young hoppers emerge and start feeding on the grasses. Later, they migrate to the main crop and start feeding on leaves. In about 70 to 80 days they become full-grown after shedding their skin five times. There is only one generation a year.

Control measures: The preventive measures are—(1) If the pest occurs annually, it is best to plough the fields and crush the egg masses by clod-crushing with a heavy plank during

April and May. Particular attention should be paid to bunds. They may be scraped to expose and destroy the egg masses, as most of the eggs are laid there.

A 5% BHC bait may be spread at the rate of about 20 lbs. to 30 lbs. per acre. This is, however, not practicable in paddy fields but may be cheaper and more useful in the case of sugarcane, particularly in the early stages, when the hoppers are on the bunds feeding on grasses. The pest is, however, very successfully and readily controlled by dusting 5% BHC powder at the rate of 20 to 25 lbs. per acre. If migration from the adioining fields occur, 2 to 3 dustings may be found necessary.

IV. THE PADDY BLUE BEETLE

Marks of identification : The beetles are slightly rectangular, small, and dark greenish-blue, smooth, about 1/4" to 1/5" in length and 1/8" in breadth. The grubs are very small. (Plate III, Figs. 1 to 4).

Nature of damage: Both grubs and beetles feed on the surface of leaves of the young paddy crop. The infestation generally takes place before flowering. They eat the green portion of leaves in characteristic and linear patches along veins, which ultimately turn white and dry up.

Host plants: Paddy and grasses.

Life history: The eggs are laid on leaves close to their tips which hatch within 4 to 5 days. The grubs on hatching start feeding on the green portion of the upper surface of leaves. Full-grown grubs pupate on the leaves from which adults emerge after about 4 days. The pest is active from July to September and several generations may occur during a season. All the stages of the insect are found on paddy plants. The pest is supposed to hibernate in wild grasses during the off season, probably as an adult.

Control measures: Mechanical measures like collecting the beetles by hand-nets or dislodging them by drawing a rope across the flooded field or by a broomstick may be of some avail when insecticides are not available.

The pest can, however, be easily checked by dusting 5% BHC dust at the rate of 15 to 20 lbs. per acre or spraying 0.2% BHC spray obtained by mixing 4 lbs. of 50% BHC water-dispersible powder in 100 gallons of water. At least 60 to 80 gallons should be used per acre. Additional precautions to be taken including clipping tips of seedlings before transplanting, so as to remove the majority of eggs and dipping the seedlings in 0.2% DDT water suspension (obtained by mixing 4 lbs. of 50% DDT water-dispersible powder in 100 gallons of water).

V. THE PADDY GALL FLY (KANE)

Marks of identification : The adult is a dipterous fly with long slender legs. The females, which are relatively swifter, have a reddish telescopic body, whereas the male of the species and those found on grasses are generally ash-grey in colour. The fly has a decumbent head with filiform antenae, consisting of 21 to 22 segments. The mouth-parts are of the sponging type. The single pair of wings is simple with only 3 longitudinal veins and the spread is about 1/15th of an inch. The halters with rounded ends have about 1/4th the spread of the wing in the normal sitting posture. The larva pupates in a brown puparium having free appendages from the body wall. The eggs are tubular with rounded ends and are pinkish in colour.

Host plants: Paddy is the main host plant. Some strains are more susceptible to the gall fly, while some show relatively good resistance. It has been observed that the Red Helga and Jaddu varieties are a little more susceptible than White Helga and Maskati. Besides paddy, about half a dozen other hosts have been traced in N. Kanara where the pest is more common. These include wild plants such as *Eragrostis* sp. *Paspalum* sp. and *Panicum* sp.

Nature of damage: The young larva after hatching creeps down the leaf sheath and gets access to the growing bud. On entering the growing bud, it seems to lacerate the tender tissues, thus spoiling the bud. Thus, normal apical growth being checked, an oval chamber called a "silver shoot" is formed round the maggot which may be due to stimulation resulting from feeding. This bud cannot produce the normal stem to bear an earhead or leaves. The damage done by this insect

can be readily distinguished from that effected by the stem-borer by the fact that Kane produces a tube-like structure in place of the growing shoot. In the case of the stem-borer, on the other hand, the normal-looking shoot dries up.

Infestation is the highest during the tillering stage of paddy, and the subsequent broods of this pest which set in after about a fortnight from the tillering stage damage the crop to the maximum extent; it does not permit the crop to recoup, as the new brood again infests the tillers which are thrown out in good number, as a result of initial gall-formation from the first and second broods of the pest.

Life history: The eggs are laid singly or in clusters on the basal side of the leaf. On hatching, the larva makes entry into the growing bud by creeping down with sheath. Each female, on an average, lays about 150 to 200 eggs.

The eggs hatch within a period of 3 to 5 days, while the larva pupates into a brown puparium within the silver shoot after about 10 days. The pupal period lasts 3 to 5 days. When about to transform into pupa, it wriggles up the silver shoot with the help of the dorsal spines of its abdominal segment, punctures the tip with its frontal spines from which the adult emerges, leaving the pupal back in the hole. Adults live for 1 to 3 days and a generation requires about 3 weeks.

Prior to attacking the paddy crop, the pest appears mainly on Giant grass (*Paspalum* sp.). On paddy, the infestation takes place from July to November. But during the later part in December, January and February, the pest occurs on sprouted stubbles but is lightly parasitised. The rabi crop following this period also shows an infestation of about 0.2 to 0.5%.

There are certain insects which live on the Kane pest and their parasitisation is greater when there is a high humidity after the Magha rains (end of August). At the same time, there is a simultaneous brood of Kane on grasses like *Eragrostis* sp. and *Panicum* sp.

Control measures: This serious pest of paddy, abundant in the North Kanara district, is very difficult to control. Satisfactory methods of control have not so far been devised. To

a great extent, however, a high humidity and subsequent parasitization are responsible for a natural check of the pest in some years. Early transplantation and use of resistant strains of paddy offer a good hope of escape from the pest. Chemical methods of control have not yet been established. Regular removal of "silver shoots" is a possible method of control. Out of the insecticides tried so far, 0.1% parathion emulsion spray has shown some promise when 5 to 7 applications were given at the rate of 100 to 150 gallons per acre at weekly intervals. However, its economics is under investigation.

VI. THE RICE HISPA

Marks of identification : The beetles are somewhat square-shaped, small and only about 1/6" to 1/8" in length and width and dark blue or blackish in colour with spines all over the wings. The presence of spines readily distinguishes it from paddy blue beetles. The grubs are small to minute. (Plate II, Figs. 8 to 11.)

Nature of damage: Both grubs and beetles injure the leaves of the paddy crop generally prior to flowering. The grub is a leaf miner and remains within the leaf tissue, feeding and creating patches on leaves which ultimately turn white and dry up. The adult is also a leaf-feeder, and starts feeding on the leaf surface in characteristic, parallel white lines which ultimately wither.

Host plants: Paddy.

Life history: The eggs are laid in the tissue of the young leaf close to its tip. The grubs on hatching start burrowing or mining into the leaf tissue, feeding on the green matter and producing characteristic blister patches on the infested leaf tips. Full-grown grubs pupate in the larval burrows and, after pupation, the adult beetles emerge. On emerging, the beetles start eating the green matter of leaves in characteristic parallel white lines on the leaf surface. Thus, the infestation of these beetles can be made out by the characteristic parallel white lines on the leaf surface and patches of leaf mines. All the stages of this pest are found on the plants and 2 to 3 generations may take place during a single paddy season.

Control measures: This pest many times appears along with the paddy blue beetle and can be readily controlled by 5% BHC dust used for blue beetle control.

VII. THE RICE-EARHEAD BUG

Marks of identification : The slender-bodied adult bugs are greenish yellow with a characteristic "buggy" odour and are a little more than ½" in length. They have long legs.

Nature of damage: Both the nymphs and the adults suck the juice from milky grains which become shrivelled as a consequence. The earheads in badly infested fields show numerous grains sucked empty and turned brown and dry, unlike the earheads of plants attacked by the stem-borer at the later stages which are completely dry including the stalk.

Host plants: Paddy and some grasses.

Life history: Brownish seed-like eggs in rows of 10 to 20 are laid on the leaf blade and they hatch in a week. The slender greenish nymphs, on hatching, start sucking the sap from grains in the milk stage and tender shoots and leaves for about a fortnight and later acquire the winged stage. The pest appears when the crop is developing earheads and is in the milky grain stage and usually disappears when the grains in the earheads become hard.

Control measures: Preventive measures include the removal of grasses along bunds and in fields before the development of earheads. Collection and destruction of egg-masses at the early stage and of adults at the later stage are also effective measures.

The pest can be successfully controlled by the insecticidal measure, namely, dusting with 5% BHC dust at the rate of 15 to 20 lbs. per acre. The dusting operation should be done in the absence of wind and early in the morning as the wetness of the leaves helps the powder to stick well.

VIII. THE RICE CASE WORM

Marks of identification : The moths are ½" in length with a wing expanse of 1¼". They are delicate and white, with pale brown and black

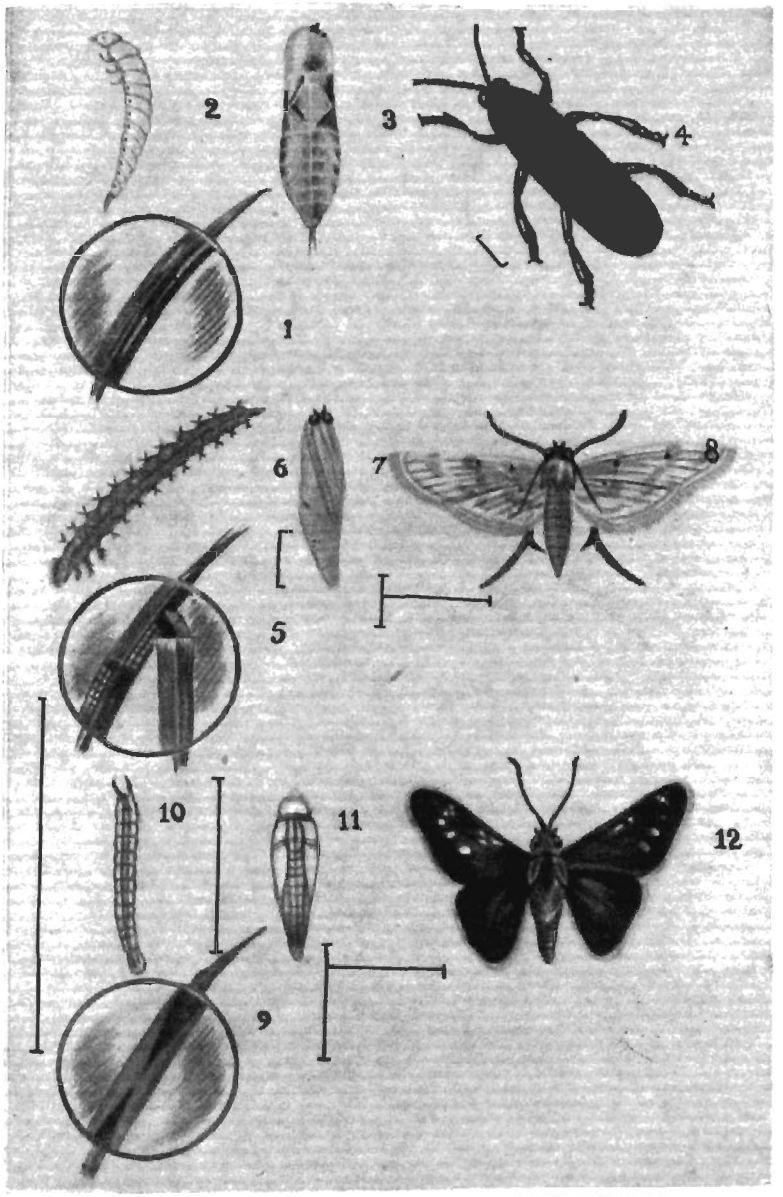

PLATE III

PESTS OF PADDY

PADDY BLUE BEETLE: *1 DAMAGED LEAF; 2 GRUB; 3 PUPA; 4 ADULT BLUE BEETLE.*

RICE CASE WORM: *5 DAMAGED LEAF WITH CASE; 6 CATERPILLAR; 7 PUPA; 8 MOTH.*

RICE SKIPPER: *9 DAMAGED LEAF; 10 CATERPILLAR; 11 PUPA; 12 ADULT*

markings. Full-grown caterpillars are greenish white, ½" long and semi-aquatic and they generally remain feeding on foliage inside tubular cases formed of pieces of paddy leaves. Hence the name "case worm". (Plate III, Figs. 5 to 8).

Nature of damage: The caterpillars cut the paddy leaves into short lengths, construct tubulars cases and remain inside them while feeding.

Host plants: Paddy and some grasses.

Life history: Tiny eggs are laid on the tender leaves. On hatching, the caterpillars cut the paddy leaves into short lengths, construct tubular cases and remain feeding inside the small rolls and there become full-grown. They pupate inside the tubular cases or rolls. Their detailed life history has not yet been investigated.

Control measures: Preventive measures include removal and destruction of the tubular cases along with the caterpillars. In the early stages of the crop before flowering, rope-dragging may be tried to dislodge the caterpillars after flooding the infested field and putting into it a little crude oil.

Insecticides recommended for the blue beetle and Hispa will also control the pest to some extent. But one part of pyrethrum extract in 600 parts of water or 0.375% DDT spray obtained by mixing 7 to 8 lbs. of 50% water-dispersible powder in 100 gallons of water has shown better results.

IX. THE RICE SKIPPER

Marks of identification : The butterflies are dark brown and about ¾" long with a wing expanse of 1½". They are active during the day. The caterpillars are green-yellowish coloured, smooth and slender when young and stout when full-fed and are about 1½" long. Two slanting red lines meeting each other at the forehead are present on the head. These red lines have other white lines inside them. Faint longitudinal stripes on the dorsal side and white stripes laterally on either side of the body are distinct in the case of full-grown caterpillars. The body segments are distinct ventrally, while the only cross yellow lines at the segmental joints are seen on the dorsal side. (Plate III, Figs. 9 to 12).

Nature of damage: The caterpillars have a tendency to remain inside the leaf by rolling it and making it like a tube.

Serious damage may occur in the moist areas with soft and late-ripening varieties of paddy crops.

Life history: These jassid hoppers generally appear by the beginning of July but only in small numbers at first and as such are not easily noticed in the fields. They lay eggs in the leaf tissues of green grass or paddy plants which hatch within about a week and the nymphs crawl about the midribs of leaves where they remain and begin sucking the sap. They also excrete a whitish sticky liquid which attracts a fungus. The nymphs attain the adult stage within two to three weeks and the adults are active from August to October. The pest is supposed to hibernate in the adult stage during the cold season. The outbreak of the pest has been recorded only in abnormal years.

Control measures: As the infestation of these jassids appears quite early even in the seed-bed areas, it is desirable to spray the plants in the seed-bed with 0.2% DDT spray obtained by mixing 1 lb. of 50% DDT water-dispersible powder in 25 gallons of water if the pest is present. Even when the pest migrates to the field proper, a thorough application of 0.2% DDT spray at the rate 60 to 100 gallons per acre, depending upon the growth of the crop, will control the pest very effectively. In the absence of DDT spray, even 5% DDT dust applied at the rate of 15 to 20 lbs. per acre gives an effective control. DDT is best for jassid control. However, dusting the infested crop with 5% BHC or spraying with 0.2% BHC suspension will reduce the jassid population somewhat but may require about two to three applications for complete eradication of the pest.

II. THE PADDY LEAF ROLLER

Marks of identification : The adult moth is small with yellowish brown wings. The full-grown caterpillars is green and a little over half an inch in length.

Host plant: Paddy.

Nature of damage: The caterpillar rolls up the leaf tips and feeds on leaves from inside by remaining inside the rolls.

Life history: The green caterpillars, on hatching from the eggs laid on the leaves of young paddy plants, start rolling the tips of leaves and become full-grown by remaining and feeding inside the leaf rolls. The full-fed caterpillars pupate inside the leaf folds. The life-cycle of this pest has not yet been worked out in detail.

Control measures: Preventive measures such as the clipping-off of the infested tips of leaves and their destruction in the earlier stages of infestation together with the caterpillars inside may be practised to check the multiplication of the pest. Insecticidal measures recommended for the control of the rice case worm also check this pest very effectively.

By M. V. KADAM, M. V. BHAT and G. A. PATEL.

CHAPTER VIII

PESTS OF SUGARCANE AND THEIR CONTROL

Sugarcane is one of the most paying crops in our State. The cost of cultivation, though high compared to other crops, pays dividends if the crop is properly cared for. Apart from the technicalities of growing cane, farmers have often to face many insect problems, the chief of which are those presented by the top shoot borer, the sugarcane grasshopper and the pyrilla. The latter two are successfully controlled by insecticidal measures, while in respect of the former cultural methods have to be resorted to. For the benefit of cane-growers, a summary of these and other pests of cane is provided here.

I. THE SUGARCANE STEM-BORER

Marks of identification : The adult moth is greyish brown or straw coloured and measures about 1½" when its wings are spread out. The lower wings are greyish white and the palpi are pointed forward. (Fig. 12, I a to I d). The newly-hatched larva is somewhat greyish in colour, having a dark head and a transluscent body with spots and hairs. The tiny spots develop into spines later. A fully-developed larva measures about 1¼" and is greyish white in colour. The body is often covered with dark marks, having tubercles and short setae on them.

Host plants : In Maharashtra State it is generally a pest of sugarcane only, but in other States it has been observed on maize and bajri as well.

Nature of damage : The pest is mainly injurious to young cane. The caterpillars enter the plants from the side at ground level by making holes in the stalk and may bore either downwards or upwards or both ways. Thus, the central shoot dries up, causing "dead hearts", which is a characteristic sign of the presence of the pest within the plants. A dead heart can easily be pulled out.

Life history : Oval, scale-like, whitish eggs are laid overlapping each other on the undersurface of leaves by the side

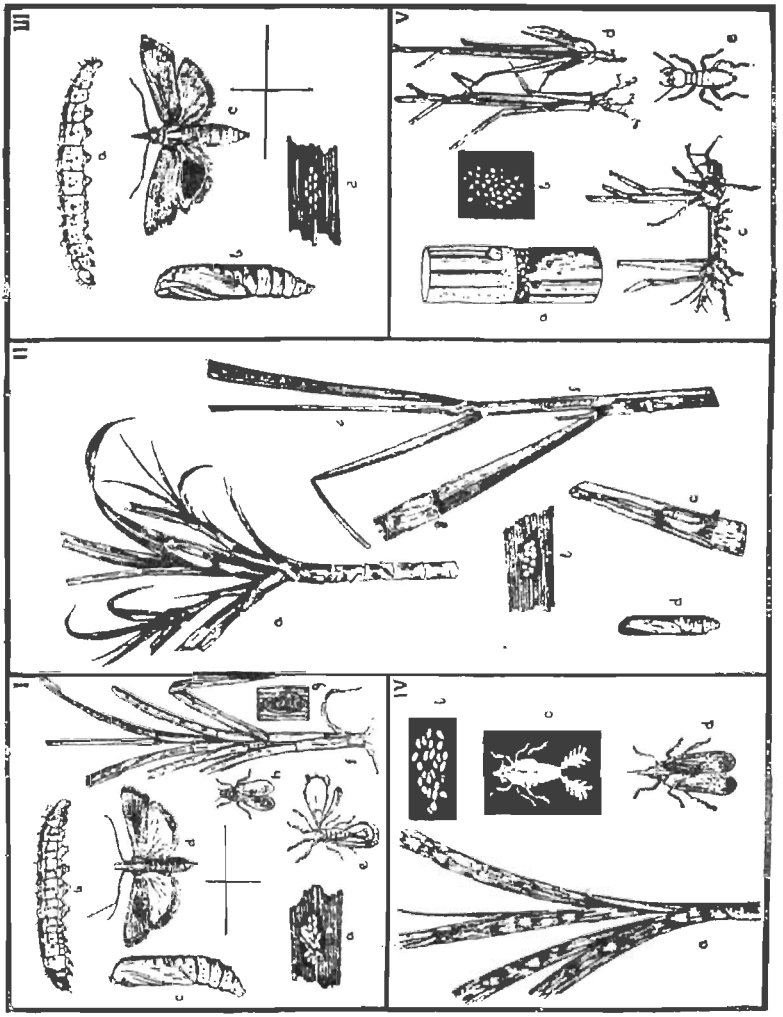

Fig. 12

SOME IMPORTANT SUGARCANE PESTS

I a to d MOTH BORER (ARGYRIA) STAGES, e EGG PARASITE (TRICHOGRAMMA) f to h MEALY WING

II a to d TOP SHOOT BORER (SCIRPOPHAGA), e to g PINK BORER (SESAMIA).

III STAGES OF BORER (DIATROEA)

IV THE CANE FLY STAGES (PYRILLA).

V a & b MEALY BUG (TRIONYMUS), c, d & e WHITE ANT AND ITS DAMAGE.

of the midrib. The egg-stage lasts for 3 to 5 days. The newly hatched caterpillar enters the cane near the eye at ground level and later tunnels as far as the roots ; sometimes, the borer is found to migrate from the roots to other tillers. The larval starge lasts for about a month and, before pupation, it bites a round hole into the cane above ground level which is covered by a silken membrane from where the moth can escape. The pupal stage lasts about a week and the entire life cycle is completed in about a month and a half. There are about eight generations in a year.

Control measures : Among these may be listed the following :

(1) Removal of affected plants having "dead hearts" right from the ground level, ensuring that the larva or pupa has come out in the portion removed and feeding the same to the cattle or burying them deep in order to prevent further development, has been tried with success.

(2) Early planting in November or December in the case of plant cane and late planting in August or September in the case of *Adsali* cane will help in minimising the infestation, as the pest is less active during these months.

(3) Trichogramma parasites (Fig. 12, I e) may be released at the rate of one lakh of parasites per acre in three instalments at an interval of a fortnight in the infested field. This has not given satisfactory control, but the cheapness of that method attracted much attention.

(4) Light earthing-up of cane will prevent the emergence of the moth by closing the holes with mud.

II. THE SUGARCANE CROP TOP SHOOT BORER

Marks of identification : The moth is creamy white in colour having a wing-span of a little over an inch when spread out and with orange hair like structures at the tip of the abdomen of the female. (Fig. 12, II a-d & Fig. 13). The first pair of wings of certain males has single black spot on each wing. Fully-developed caterpillars measure about 1 inch to 1½ inches in length and are yellowish white in colour.

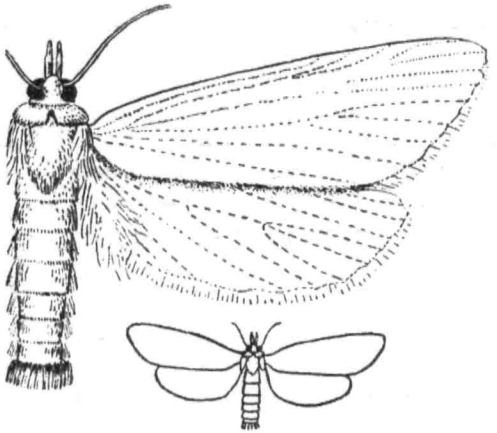

Fig. 13
THE TOP SHOOT BORER MOTH

Host plants : In our State mostly sugarcane, but in other States jowar has been recorded as a host plant.

Nature of damage : This is a very serious pest of sugarcane that breeds throughout the year and is capable of attacking cane at a later stage. The newly-hatched caterpillars enter first the midrib of the leaf and bores downwards into the shoot from the top. As a result of such feeding, the central shoot dries up in a characteristic way, which later results in giving off side shoots which form a bunchy top. The punctures on the leaves and the death of the central shoot and the bunchy top are the characteristic effects of this pest.

Life history : Eggs are laid on the undersurface of leaves in groups consisting of 35 to 40 eggs which are covered with brownish hair-like structures and hence are clearly visible. The newly-hatched caterpillar, after remaining for some time on the leaves, enters the shoot through the midrib of the leaf. The caterpillar feeds as it travels downward. A fully-developed larva measures 1 inch to 1½ inches and, before pupation, it prepares a silken membrane from which the moth can escape. The pupa is found in the larval tunnel. The egg-stage lasts for 6 to 7 days, while the larval period continues for 3 ot 6 weeks. The pupal stage continues for 7 to 10 days from which the moth on emergence lays about 5 to 8 egg-masses within two or four days of its life-time.

Control measures : (1) Mechanical methods such as mass collection and destruction of egg-masses and removal of affected plants are the only effective measures known so far.

(2) Conservation of egg-parasites with the help of special boxes can be tried. Chemical measures have not yet proved successful. However, for effective control of the shoot borer in general, the following measures are recommended :—

1. The crop should be harvested by digging out the stump and not by cutting at ground level.

2. A large-scale campaign to collect and destroy the egg-masses of the top shoot borer should be carried out.

3. Two light earthings-up should be given during the early stages of the crop.

III. THE SUGARCANE GRASSHOPPER

Marks of identification : The adult grasshopper is medium-sized, about 2" in length including the wings, and greenish in colour with blue tibia and 2 to 3 black lines on the saddle-shaped pronotum just behind the head. (Fig. 11). The nymphs are tiny grasshoppers initially brownish black in colour and without wings.

Host plants : Sugarcane and paddy are its main hosts but it may feed on other cereals also. The pest is also called the rice grasshopper.

Nature of damage : The nymphs and the adults feed on leaves and in case of a severe attack completely defoliate the plants, leaving only mid-ribs. Consequently, the growth of cane suffers and the plants remain stunted and ultimately the yield is affected. In the early stages, the nymphs may feed on grasses on bunds.

Life history : The eggs are laid in masses of 30 to 40 each at a depth of 2" to 3" in the soil on bunds and other high-lying undisturbed places during the period from October to December. The eggs remain in the soil till May or June of the following year. With the start of the monsoon, the eggs hatch out into small actively jumping hoppers that are brownish black in colour. They turn reddish as they grow and final-

ly become greenish within a period of about 2½ months during which they pass through several moults, ultimately reaching the adult stage which mates and lays eggs in the soil.

Control measures: (1) Dusting the affected crop with 5% BHC at the rate of 20 to 25 lbs. per acre is quite effective. In the initial stages when the infestation is on the bunds, dusting may also be done. In case of a severe attack, dusting will have to be repeated. (2) Ploughing the affected fields and the bunds to a depth of 4" to 6" followed by breaking the clods, should be done after harvesting the crop if the pest is to be kept under check. The egg-masses in the soil are expressed by this measure. (3) In the affected area, ratooning should be discouraged.

IV. THE SUGARCANE LEAF-HOPPER OR PYRILLA

Marks of identification : *The adult pyrilla bug is a straw-coloured insect,* with two pairs of wings folded roof-shaped on the back and with its head extended like a pointed beak which is quite readily visible. The young nymphs that hatch out from the eggs are pale brown in colour, having a *pair of long characteristic processes covered by wax. They are active and* are found in large numbers on cane. (Fig. 12, IV and Fig. 14).

Host plants: Its host plant is mainly sugarcane but adults are sometimes found in small numbers on jowar and maize.

Nature of damage : The nymps and adult bugs suck the sap of cane leaves from the lower surface, as a result of which the leaves lose turgidity, begin to wither and ultimately get dried up. The bugs secrete a honeydew-like substance that spreads on the leaves on which a black fungus develops. As a result of pyrilla damage, the sucrose content of the juice is reduced.

Life history : Pale greenish-yellow eggs are laid in clusters of 2 to 4 or 10 to 60, generally on the undersurface of leaves and between the detached leaf sheaths and the stem. The eggs are covered with white cottony, waxy filaments. They hatch out within a week into tiny hoppers that start sucking the sap of leaves. The nymphs become adult bugs within 50 to 60 days. Egg-laying continues from April to

November and the period of its great activity is July and August.

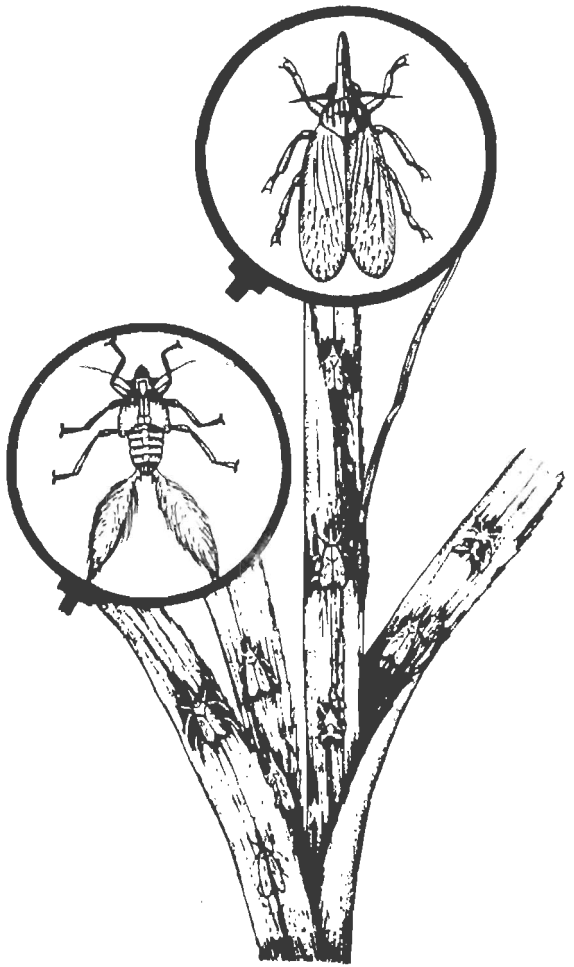

Fig. 14
ADULT PYRILLA AND THEIR NYMPHS ATTACKING A SUGARCANE PLANT

Host plant : Sugarcane.

Control measures : (1) Collection and destruction of egg-masses and crushing the egg masses between fingers on the leaves is found to be a convenient method of control. (2) Strip-

ping off the lower leaves to remove the eggs laid in the leaf-sheath was a method recommended for a long time. Now, however, insecticides are used. (3) Dusting the crop with 5% BHC at the rate of 30 to 40 lbs. and 50 to 60 lbs. per acre in the pre-and post-monsoon periods, respectively, destroys both the nymphs and the adults. This method is now widely used. (4) Spraying 0.12 to 0.25% BHC or 0.25% DDT at the rate of 30 to 50 gallons per acre for young cane during the pre-monsoon period and over 100 gallons during the post-monsoon period also gives considerable relief. (The quantity to be used depends on growth of cane and enough quantity should be used so as to cover the entire crops.)

V. THE MEALY BUG ON SUGARCANE

Marks of identification : Adults and nymphs of mealy bugs are soft-bodied, light-coloured, oval creatures, found in large numbers near the nodes, covered over by a white, waxy powder and in the leaf sheath. (Fig. 12, V a to b).

Nature of damage : Being a minor pest, its damage to the crop is not considerable. The adults and the nymphs being lodged in leaf-sheaths continuously suck the sap and weaken the plant and, in case of excessive infestation, decrease the yield.

Life history : The female deposits hundreds of eggs covered with a white waxy or mealy mass. The newly-hatched nymphs travel rapidly for some time to find new places for settling on the plant. The ants help a great deal in their dispersal and live a symbiotic existence by getting honeydew secreted by mealy bugs in return.

Control measures : (1) Selection of sets free from the infestation of mealy bugs in one method. The sets may be treated with 1% fish oil rosin soap before planting. (2) The affected plants should be sprayed with 1% fish oil rosin soap which gives some relief.

VI. THE MEALY WING OR WHITE FLY

Marks of identification : The adults are active, tiny creatures with a pale body, black eyes and a pair of mealy white wings. The nymph is a tiny pale yellow creature. (Fig. 12, I f to h).

Host plant : Sugarcane.

Nature of damage : *By sucking the sap from the leaves,* the nymphs and the adults affect the vigour of the cane. In general, it is a very minor pest and is rarely troublesome.

Life history : Small eggs are laid in the middle of the lower surface of leaves, which hatch out within about a week. The young ones require 3 to 4 weeks for becoming mature adults.

Control measures : (1) Clipping off and destroying the early infested leaves prevent further spread. (2) Spraying the affected area with 1% fish oil rosin soap or rosin compound in case of serious innfestation gives some relief.

VII. WHITE ANTS ON SUGARCANE

Nature of damage : The termites attack the planted sets either near the eye bud or from the cut end. They occasionally attack the entire roots through which they ascend the cane, which they fill with mud galleries.

The following control measures against termites on sugarcane are recommended.

(1) The sets may be dipped into 0.25% BHC suspension or 1.25% DDT suspension or they may be soaked in a mixture of lime and lead arsenate in the proportion of 10 : 1 for 24 hours before planting.

(2) At the time of planting, 5% BHC dust at the rate of 20 lbs. per acre should be applied in furrows along with the sets.

For details, see Chapter 18 on termites and their control.

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CHAPTER IX

PESTS OF PULSES

In Maharashtra State, the common pulse crops are *tur*, gram, peas, *mung*, *chavali*, and such other beans. Generally, the frequency of pest epidemics on these legumes is considerably less, but some pests like aphids on peas occur annually in many areas, particularly in the Deccan. Other pests like the gram pod-borer assume epidemic proportions only under favourable climatic conditions, though the pest is common in small numbers in many areas of the State. Some other pests like the pod-bug, on the other hand, have not been known to become abundant. The life history and control of these and other pests will be found hereafter.

PESTS OF GRAM

I. THE GRAM POD-BORER

Marks of identification : The moths are stout, light yellowish brown, with a wing expanse of 1½". The forewings are pale brown with some black dots, and the hind wings are lighter in colour with smoky dark margins. The caterpillars are greenish with darker broken grey lines along the sides of the body. They are 1½" to 2" in length when full-grown. (Fig. 15).

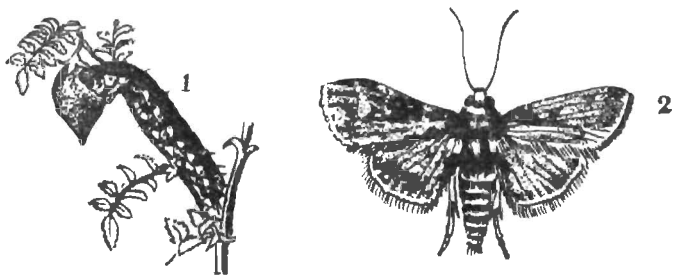

Fig. 15
THE GRAM POD-BORER
(Chloridia) (Hellothis) obsoleta (armigera)
1. THE CATERPILLAR 2. THE MOTH

Nature of damage : The caterpillars feed on tender foliage and young pods. They make holes in the pods and eat the developing seeds by inserting the anterior half-portion of their body inside the pods.

Host plants : Gram, cotton, tomato, peas, tobacco, ganja, safflower, etc., are the principal hosts.

Life history : Shining greenish yellow eggs, spherical in shape, are laid singly on the tender parts of plants and they hatch in about 6 or 7 days. On hatching, the caterpillars start feeding on tender leaves and shoots and, as they grow, they bore into the pods and eat the developing grains inside. They become full-grown in 14 to 15 days and descend to the ground and pupate in earthen cocoons in the soil near the plants. Their pupal period lasts from one week to a month. The pest is active from November to March.

Control measures : Preventive measures include hand-picking of caterpillars and their destruction in the early stages of attack. Thorough ploughing after harvesting the crop in order to expose pupae is also often resorted to. The pest can be controlled by 0.2% DDT spray obtained by diluting 1 lb. of 50% water-dispersible DDT powder in 25 gallons of water. About 60 to 80 gallons on a young crop and 100 gallons on a grown-up crop are generally required.

PESTS OF TUR

The pests of *tur* are : (i) The tur-pod caterpillar (Plume moth), (ii) the tur-pod bug and (iii) aphids.

I. THE TUR-POD CATERPILLAR

Marks of identification : The moths are slender, not more than ½" long and are grey with long, narrow wings. The front wings are divided into two parts and the hind wings are cut up into three parts and provided with a fringe-like border. (Fg. 16). The full-grown caterpillars are about ½" long, greenish-brown in colour and are fringed with short hairs and spines.

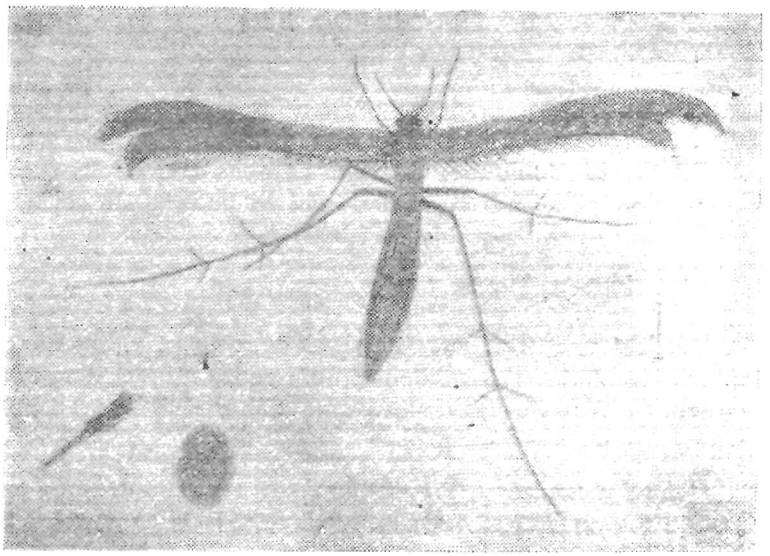

Fig. 16
THE TUR PLUME MOTH

Nature of damage : The caterpillars bore into green pods and feed on the developing seeds.

Host plants : *Tur* and *Wal.*

Life history : Minute eggs are laid singly on the tender shoots, leaves, flowers or pods, and they hatch in about 5 days. On hatching, the caterpillars first scrape the surface of pods and gradually cut holes and thrust their heads into pods and feed on seeds and become full-grown in about four weeks' time. They pupate on the pod surface or even in the burrows of infested pods. Their pupal period lasts two weeks. The pupae are also fringed with short hairs and spines and are often liable to be mistaken for larvae. The total period of their life-cycle is about seven weeks.

Control measures : Preventive measures are the collection of caterpillars by shaking shoots and pods in small trays containing kerosenized water and avoiding to take leguminous crops in the same fields in successive years. The insecticidal measures given under the gram-pod borer may be tried with advantage.

II. THE TUR-POD BUG

Marks of identification : The adult bugs are about half an inch long, are greenish brown in colour, have a spined pronotum and a femur swollen at the apical end.

Nature of damage : Both the nymphs and adults suck the sap from pods and cause the infested pods to shrivel up. The pest, however, is rarely serious.

Host plants : *Tur, Wal,* etc.

Life history : The eggs are laid in rows. On hatching, the nymphs start sucking the juice from pods and pass through five moults to reach the adult stage. Other details have not so far been worked out.

Control measures : Preventive measures are the same as those in the case of the pod caterpillar. 5% BHC powder, if dusted at the rate of 15 lbs. per acre, may also help control the pest.

PESTS OF PEAS

There are three common pests of peas. They are : (i) The leaf-eating caterpillar, (ii) The pod-borer, and (iii) aphids. Any one of these may become serious if favourable conditions prevail.

I. THE LEAF-EATING CATERPILLAR

This is discussed under lucerne below.

II. THE POD-BORER

Details of this pest are the same as those for the gram pod-borer.

III. APHIDS

These are discussed under vegetable crops. (Chapter XI).

PESTS OF MUNG, UDID, CHAVALI AND BEANS

APHIDS

For details see Chapter XI.

PESTS OF LUCERNE

I. THE LUCERNE LEAF-EATING CATERPILLAR

Marks of identification : The moths are medium-sized with dark-spotted forewings and whitish shining bluish hind wings. The caterpillars are about an inch long, brownish green, with a narrow dark line along the back.

Nature of damage : The caterpillars feed on leaves generally during mornings and evenings and, in serious cases of attack, defoliate the plants.

Host plants : Lucerne, onion, garlic, pulses, safflower, linseed, cruciferous vegetables, tomato, brinjal, cotton, etc.

Life history : The eggs are laid on leaves in clusters which hatch in 2 to 3 days. On hatching, the caterpillars start eating the leaves in the morning and the evening and become full-grown in a period of two weeks. During feeding, if they are even slightly disturbed they fall to the ground. Pupation takes place among dried fallen leaves and in the soil. The pupal period is one week and the total period of their life-cycle is 3 to 4 weeks. The pest is active on lucerne during summer.

Control measures : The usual measures, including flooding the infested fields with the addition of a little quantity of crude oil or dusting the field with 5% BHC at the rate of 15 to 20 lbs. per acre after cutting, may be tried. The remaining pests of lucerne, viz., aphids and thrips, are discussed elsewhere in this book.

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CHAPTER X

PESTS OF SOME VEGETABLES

Three common vegetables have been dealt with here viz., the potato, the sweet potato and the brinjal.

POTATO

The common pests on this crop are the following :

(i) Cut worm,
(ii) Leaf-hopper,
(iii) Potato tuber-moth,
(iv) Epilachna beetle, and
(v) Mites.

I. 'CUT WORM

Marks of identification : Full-grown caterpillars are about three-quarters of an inch long, dirty black in colour and have a habit of coiling up at the slightest touch. As they become old, they live in cracks of soil near about the base of plant during the day-time and feed on young plants at night. The moths are about an inch long with dark or blackish grey patches on their forewings and are attracted by light. (Fig. 17).

Nature of damage : The caterpillars are active during the night. They cut the young plants at the ground level and feed on tender leaves and shoots. They cut many more plants than they can eat.

Host plants : Potato, tobacco, peas, gram, cotton, tomato, lucerne, chillies, brinjals and other vegetables.

Life history: Creamy white spherical eggs are laid singly quite near to one another on the lower surface of leaves and stems close to the ground. The egg-laying capacity of a single female is about 300 eggs. The eggs hatch in a period of 4 to 7 days. Newly-hatched caterpillars are light-grey coloured and move as a semi-looper. The caterpillars become full-grown in about 3 to 5 weeks' time and pupate in the soil in earthen cocoons. The pupal period is 11 to 18 days. The total period

of their life-cycle in cold weather in the plains is about 5 to 9 weeks and there are generally two generations a year.

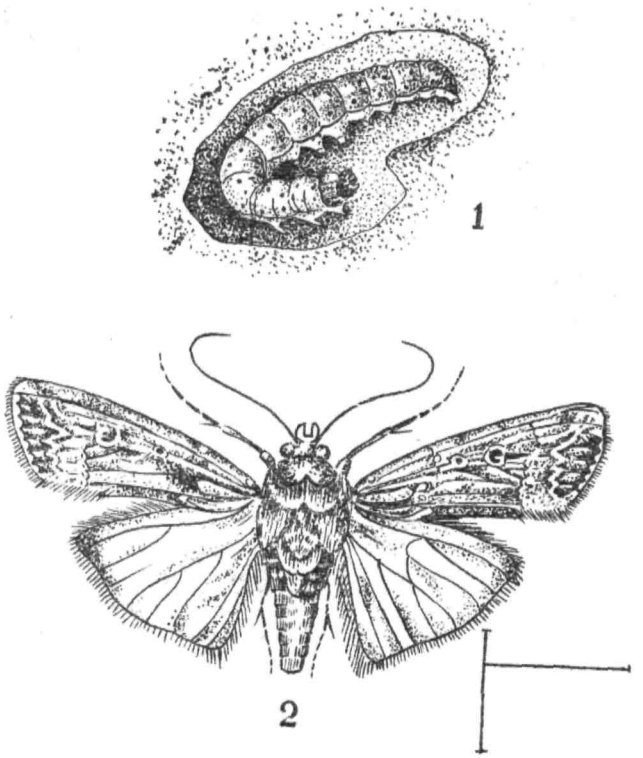

Fig. 17
CUT WORM

Control measures : (1) Clean cultivation by way of regular interculturing and stirring-up of soil below the plants should be practised. (2) Heaps of green grasses may be kept at suitable intervals in the infested fields in the evening, so that the caterpillars come and seek shelter below them. In the morning, the heaps along with the caterpillars may be destroyed. (3) If possible, irrigation will also bring the caterpillars to the surface, when birds will destroy them. (4) This pest is successfully controlled by the use of poison baits of 5% paris green or benzene hexachloride. They may be profitably

broadcasted along the rows of plants or around the plants in the evening but not in the morning. The rate is about 20 lbs. per acre. A slightly higher rate may be used without any danger. The bait remains effective only for a day or two and hence the treatment may be repeated if control is not obtained by a single treatment.

The composition of bait is :

Wheat bran	... ...	25 lbs.
Paris green	... ...	1 lb.
(or 50% wettable BHC	... ...	2½ lbs.)
Molasses	... ...	2½ lbs.
Water	... ...	sufficient to moist the bait

The bait is prepared by dissolving the molasses in water and then mixing the poison. Use this sweet mixtures to wet the bran. Some quantity of water may be added, if necessary, to prepare a homogeneous mixture for use.

II. LEAF-HOPPER

Marks of identification : The adults are greenish-yellow with front wings having a black spot on each wing on the apical margin and two black spots on the vertex of the head. The nymphs are also greenish and, like adults, they walk diagonally.

Nature of damage : Both nymphs and adults suck the sap from the lower surface of the leaves. The damaged leaves curl upwards along the tips and margins, which may turn yellowish and show burnt-up patches. Excessive damage of leaves leads to reduction of tuber formation.

Host plants : Cotton, Bhendi, potato, brinjal and other malvaceous plants.

Life history: Whitish eggs are laid in the leaf tissues along the veins which hatch in about a week. On hatching, the nymphs start sucking the sap from the lower surface of the leaves and become adults in one to two weeks, depending upon the temperature. There are 5 moults in the nymphal

period. This pest is common throughout the year, but is more abundant in the Kharif season.

Control measures : The older method of control of this pest consisted of spraying the affected crop with fish oil rosin soap in the proportion of ½ lb. in 4 gallons of water or nicotine sulphate diluted in water in the proportion of 1 : 800 or rosin compound which does give a satisfactory measure of control. The total quantity of the spray required to treat an acre of field will vary from 80 to 100 gallons, depending upon the growth of the crop.

This pest is, however, successfully controlled by dusting 5% DDT plus sulphur dust mixed in the proportion of 1 : 1 or 1 : 2 at the rate of 15 to 20 lbs. per acre. Sulphur is known to cause damage to indigenous varieties of cotton and it should not be used on them.

III. POTATO TUBER MOTH

Marks of identification : Full-grown caterpillars are three-quarters of an inch long, pinkish-white or greenish with a dark brown head. The moths are very small, narrow-winged, measure half an inch from tip to tip of the wing and are greyish brown in colour, mottled with hue of a darker brown. (Figs. 18 and 19).

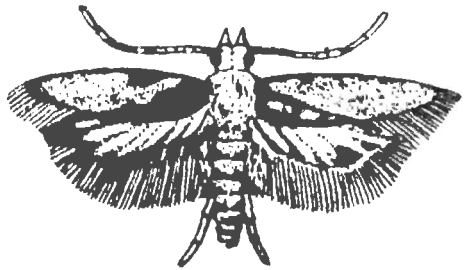

Fig. 18
POTATO TUBER MOTH (X 4)

Nature of damage : In the early stages of the crop, the pest injures the plant as a leaf miner, but this injury seldom attracts much attention. The main danger is to tubers both in the field and under storage. Ultimately, the infested tubers rot. The activity of the pest in stored potatoes can be gener

ally made out by the presence of black excreta near the eye buds. On cutting open one of such potatoes, one finds the caterpillar in the pulp. (Fig. 20).

Host plants: Potato, tobacco, tomato, egg-plant, and weeds of the same family.

Fig. 19
FULL-GROWN CATERPILLAR (X 3)
POTATO TUBER MOTH

Life history : The eggs are laid singly on the underside of leaves or on exposed tubers. On hatching, the caterpillars produce blotch mines on the leaves and subsequently bore into the stems and become full-grown in 2 to 3 weeks. Full-fed caterpillars pupate in a greyish, silken dirt-covered cocoon, about half an inch in length and entangled in dried leaves or in trash lying on the ground. The pupal period lasts 7 to 10 days. The total period of their life-cycle is about 4 weeks in warm weather. Warm weather is most favourable for the spread of this pest and there are several generations a year. The later generations infest the tubers in the field and come out of them for pupation.

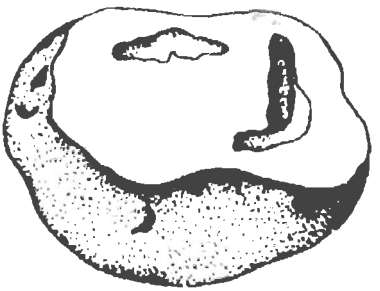

Fig. 20
POTATO CUT OPEN TO SHOW CATERPILLAR AND DAMAGE DONE BY IT

Control measures : (1) A proper earthing-up may be

tried in order to cover the growing tubers in the field. (2) A few days before harvest, all the affected plants and tubers may be removed. (2) Heaps of the harvested tubers should not be kept exposed in the field. (4) Before storing, the harvested tubers may be fumigated with carbon disulphide at the rate of 5 lbs. per 100 c.ft. for 48 hours when the temperature is above 70° F. or methyl bromide at the rate of 2½ lbs. per 1,000 c.ft. for at least 3 hours. (5) The bags to be used for storing potatoes may be treated with 1% solution of DDT in xylene. (6) Infestation of leaves by the pest in the field may be controlled by dusting the plants with 3% to 5% DDT at the rate of 24 lbs. per acre or spraying them with DDT at the rate of 2 lbs. of 50% wettable powder in 100 gallons of water. This is, however, rarely found necessary in Bombay State.

IV. EPILACHNA BEETLE

Marks of identification : The grubs are yellowish in colour and stout-bodied, with stout hairs on their bodies. The beetles are spherical and pale brown and mottled with black spots. There are two species—one having 8 spots and another having as many as 28 spots. (Figs. 21 and 22).

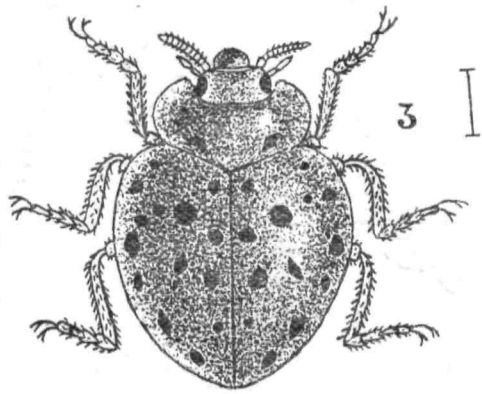

Fig. 21
EPILACHNA BEETLE

Nature of damage : Both grubs and beetles eat the chlorophyl of the leaf in between the veins and cause characteristic skeletonized patches on leaves.

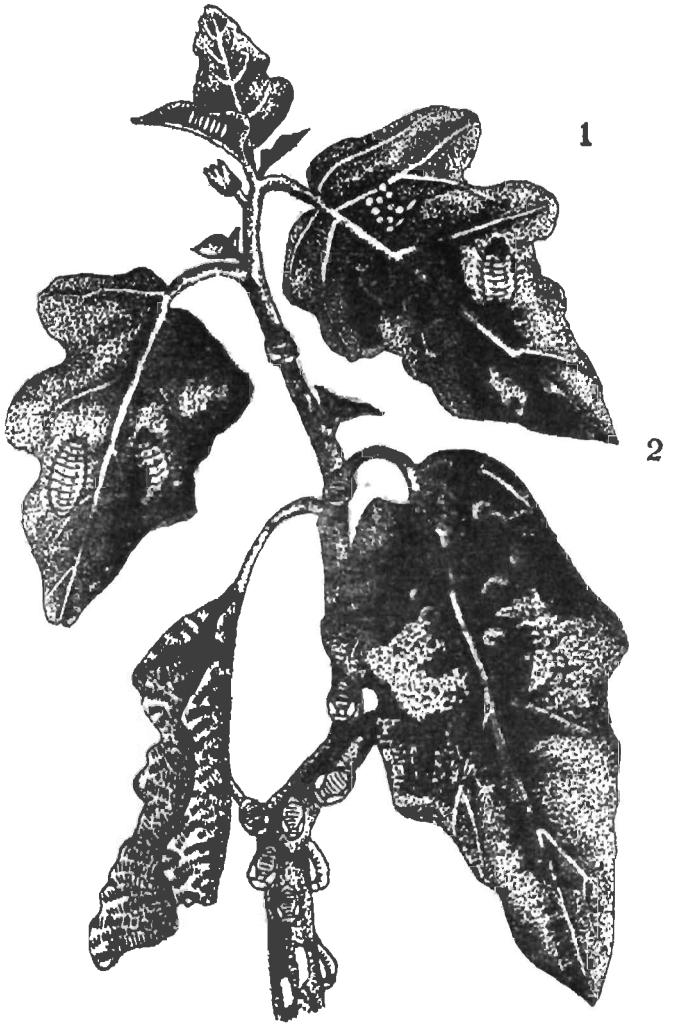

Fig. 22
EPILACHNA BEETLE
1. Eggs 2. Larva

Host plants : Potato, brinjal, Karli, and wild cucurbits.

Life history : Yellowish, elongated eggs are laid in batches on the leaves, with their tips pointing upwards. On hatching, spiny, yellowish grubs start feeding on the green material

of leaves. Full-grown grubs pupate on the leaves. The pupae are hemispherical in shape and are found attached to the leaves. All the stages of the pest are found on the plants only.

Control measures : They are : (1) Collection of beetles by hand-nets and of grubs by employing boy labour in the early stages of attack is a handy method. (2) In serious cases of attack, the crop may be sprayed with lead arsenite in the proportion of 1 oz. in 4 gallons of water. (3) Dusting by 5% BHC dust may also be tried. BHC ordinarily sold as crude BHC gives a bad odour to the potato and hence for this crop pure gamma BHC (known as lindane) should be preferred, though it is costlier. It may be used as 0.65% dusting powder.

V. MITES

Marks of identification : Mites are not insects, as they have 4 pairs of legs and belong to the class Arachnida, which includes spiders, ticks, scorpions, etc. They are extremely minute with variable colour.

Nature of damage : They suck the sap from leaves. Badly-attacked leaves show a particular bronzy and shiny appearance and ultimately wither and dry up.

Host plants : Potato, citrus, cotton, jowar, etc.

Life history : The eggs are laid on the leaf surface from which young ones hatch out, feed on the host plants and grow into wingless adults. Some plant-feeding mites cause galls on the leaves and others cause reddening or browning, as on jowar; silvering and bronzing are observed on guava, cotton, citrus, etc.

Control measures : Spraying with a lime sulphur wash is a reliable method. Ready-made lime sulphur can also be used. Dusting sulphur mixed with lime in the proportion of 1 to 2 is frequently resorted to with success. Lime sulphur is prepared as follows. The ingredients are :

Quick lime	5 lbs.
Sulphur	10 lbs.
Water	5 gallons.

First slake quick lime and then add sulphur and enough of water to make up 5 gallons. Boil the mixture for about an hour (keeping the volume constant), until it assumes a brick-red colour. *Dilute* the mixture with required parts of water as is described under lime sulphur in the chapter on insecticides. The usual dilution is 90 times if the stock solution is well prepared.

BRINJAL

(i) Brinjal shoot and fruit borer,
(ii) Brinjal leaf-roller,
(iii) Epilachna beetle,
(iv) Jassid, and
(v) Aphid.

I. BRINJAL SHOOT AND FRUIT BORER

Marks of identification : The moths are medium-sized and have whitish wings with large brown patches all over. The head and thorax are blackish brown. The caterpillars are pale white about half an inch long when full-grown. (Fig. 23).

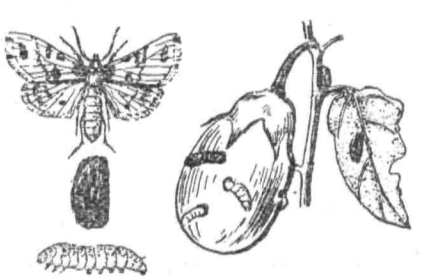

Fig. 23
BRINJAL FRUIT BORER

Nature of damage : The caterpillars bore into the stem and riddle it and eat the internal tissues and thus cause the plants to wither. When the infestation is on shoots, they bend down and wither. They attack the fruits as well, making their entry under the calyx when they are young, leaving no visible signs of infestation. The large holes seen on fruits are usually the exit holes of the caterpillars.

Host plants : Brinjal and stems of potato.

Life history : Flat, whitish eggs are laid scattered on the leaf surface which hatch in 3 to 5 days. On hatching, the

caterpillars start boring into the tender, growing shoots of plants and when fruits are formed, they bore into them. They feed on the internal part of the shoots or fruits and become full-grown in 7 to 13 days. Full-grown caterpillars come out of the larval burrow and pupate in boat-shaped cocoons. Their pupal period lasts 7 to 11 days.

Control measures: (1) Removal and destruction of the affected fruits and shoots along with the caterpillars inside is a simple method. (2) Continuous cropping of the brinjal and potato leads to more infestation and hence should not be indulged in. (3) Brinjals with long, narrow fruits are less susceptible to attack. (4) Chemical control has not yet been tried.

II. BRINJAL LEAF-ROLLER

Marks of identification : The moths are medium-sized, having a wing-span of 1½" and are olive green in colour. The caterpillars, when full-grown, are stout, beautiful purple brown with yellow spots and hairs and are usually found in rolled-up leaves.

Nature of damage: The caterpillar rolls up the leaves and feeds on the green matter while remaining inside the folds and thus leads a concealed life, ultimately, the folded leaf withers and dries up.

Host plant: Brinjal.

Life history: The eggs are laid on leaves and they hatch in 3 to 5 days. On hatching, the caterpillars fold the leaves from the tip upwards and feed on the green matter by remaining inside the folds. Full-grown caterpillars pupate inside the folds.

Control measures: (1) Removal and destruction of the folded leaves along with the caterpillars inside is a direct device. (2) As the caterpillars remain inside the folds, insecticides sprayed or dusted do not usually reach them satisfactorily. However, spraying with 4 lbs. of 50% DDT wettable powder diluted in 100 gallons of water may be tried if other methods prove of little avail.

The remaining pests are described under potato and for aphid refer to chapter on sufflower or cotton or Chapter XI.

SWEET POTATO

The important pests of the sweet potato are the sweet potato leaf-eating caterpillar and the sweet potato weevil. The latter is of more serious consequence than the former.

I. SWEET POTATO LEAF-EATING CATERPILLAR

Marks of identification : The moths are grey-coloured marked with black and a little angular with apparently a pointed head. The abdomen has pink and white lateral bands. The caterpillars, when full-grown, are about 3 inches to 4 inches long with a sharp curved anal horn at the tail end and are dark-brown in colour.

Nature of damage: The caterpillars eat the leaves.
Host plants : Sweet potato, *mug* and *udid*.

Life history: The eggs are laid singly on leaves and they hatch in 5 to 10 days. On hatching, the caterpillars start feeding on leaves and become full-grown in a period of 14 to 21 days. Full-grown caterpillars pupate in the soil. Their pupal period is 7 to 11 days. The pest hibernates as pupae. The total period of its life-cycle is 2 months and the pest is active during the monsoon.

Control measures: (1) Hand-picking of the caterpillars and their destruction in the early stages of attack is a common practice. (2) Thorough ploughing after the harvest of the crop to expose the pupae is also effective. (3) 5% BHC dust can also be tried.

II. SWEET POTATO WEEVIL

Marks of identification : The adults are weevils which are wingless, small and steel-black, with a brown elongated snoulike head and the thorax is coloured like the head. The grubs are pale yellow in colour. (Fig. 24).

Nature of damage: The grubs bore into the stems of vines and also into the tubers in the field as well as in godowns, and spoil them. Their presence inside the tubers

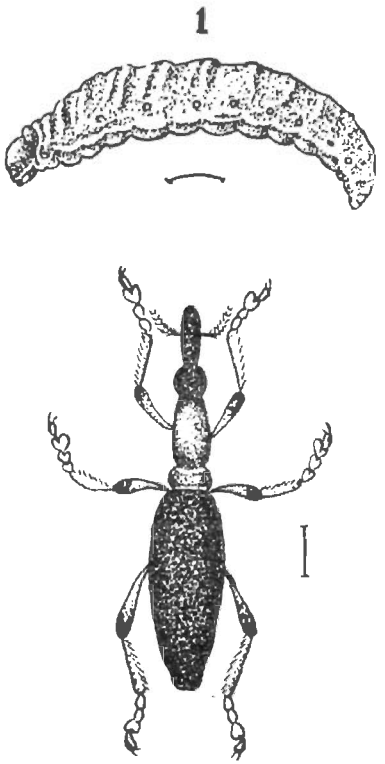

Fig. 24
SWEET POTATO WEEVIL
(Top) Grub (Bottom) Adult Weevil

can be made out by the development of dark black patches on them.

Host plant: Sweet potato only.

Life history: The female weevil makes small cavities on the tubers and stems of vines and lays eggs which hatch in 5 to 7 days. On hatching, the grubs start boring into vines or tubers, feed on the internal tissues and become full-grown in 2 to 3 weeks. Full-grown grubs pupate in the larval burrows. Their pupal period lasts about 7 days. The total period of their life-cycle is 4 to 5 weeks. The insect is carried from one field to another through the infested vines and also

from season to season by breeding in tubers left over after harvest.

Control measures: (1) Select healthy cuttings for fresh planting from uninfested areas. Before planting, they may be dipped into a mixture of 1 lb. of lead arsenate in 10 gallons of water. (2) Follow a system of proper rotations. (3) After the harvest of the crops, the remains of the crops should be collected and destroyed completely. (4) Spraying the crop at 10 days' interval with lead arsenate in the proportion of 2½ lbs. in 100 gallons of water or dusting at a 2-week interval with calcium arsenate or 10% toxaphene, has been recommended in the U.S.A. for the control of this pest.

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CHAPTER XI

PESTS OF CRUCIFERS, CHILLIES, ONIONS, CUCURBITS AND BHENDI

The important pests of crucifers are (i) the mustard saw-fly, (ii) the diamond back moth, (iii) the painted bug, and (iv) aphids. Some of these are of regular occurrence in our State, while others like the painted bug, though seen in small numbers every year, rarely make their appearance in the form of an epidemic. Among those of frequent occurrence are the aphids and the mustard saw-fly, which attract more frequent attention than the other two.

I. MUSTARD SAW-FLY

Marks of identification : The adult flies are short and thick-bodied, and are marked with black and orange. Their wings are smoky with black veins and though called "flies", they have four pairs of wings. Full-grown larvae are three-quarters of an inch long, black, smooth with 8 pairs of prolegs, in addition to three pairs of true thoracic legs, and have 5 long stripes on the body. On being touched, they have a tendency to curl up and drop on the ground, feigning death. (Figs. 25 and 26).

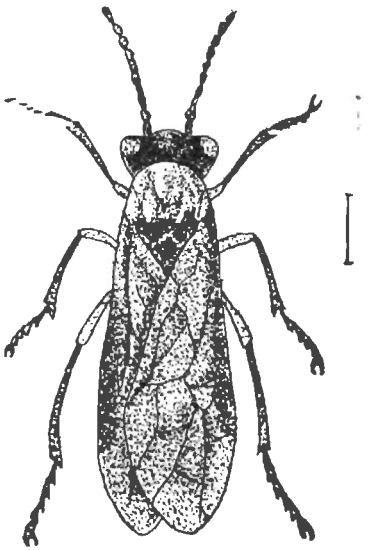

Fig. 25
MUSTARD SAW-FLY

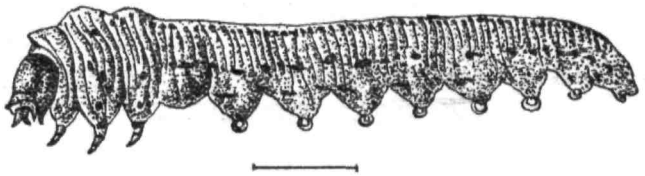

Fig. 26
MUSTARD SAW-FLY
Larva

Host plants: Raddish, cabbage, Brussel sprouts, cauliflower, mustard and turnip.

Nature of damage: The larvae feed on leaves by cutting small holes into the leaves and ultimately skeletonize the plants. Frequently, a large number of larvae can be found on each leaf.

Life history: The eggs are laid singly in the leaf tissues and hatch in about a week's time. On hatching, the larvae start feeding on leaves from the margin inwards. They feed in the morning and evening for about a fortnight and grow. Full-fed larvae descend to the ground and pupate in the soil in earthern cocoons. Their pupal period lasts 10 to 12 days. The pest is active from October to March.

Control measures : (1) In the early stages of attack, hand-picking of the larvae and their destruction may be resorted to. (2) Shaking the affected plants in a tray containing kerosenized water is a common method. (3) Spraying pyrethrum extract (1:800) may be tried when the infestation is very heavy.

II. DIAMOND BACK MOTH

Marks of identification : The moths are small, about one-third of an inch long and brownish-grey in colour. The lower edge of the front wing has white coloured patch, which appears like the shape of diamond when both the wings are closed; hence the name. Full-grown caterpillars are greenish, half an inch long, moderately stout, somewhat tapering at both ends and smooth, with some scattered hairs.

Host plants: Cabbage, mustard, cauliflower and *knol-khol.*

Nature of damage : The caterpillars feed generally on under-surface of leaves and make holes into them and may skeletonize the plants when they are present in strength.

Life history : Pale, whitish eggs are laid singly on the lower surface of leaves and they hatch in about a week's time. On hatching, the caterpillars feed on leaves for about 14 days and become full-grown. Full-grown caterpillars pupate on the leaves in thin silken cocoons. Their pupal period lasts a week. The pest is active from September to March and there are about 5 to 7 generations in a season.

Control : (1) In the early stages of the crop, spraying with a stomach poison like calcium arsenate at 4 to 8 lbs. in 100 gallons of water has been found effective. (2) Spraying with pyrocolloid in the proportion of 1 part in 800 parts of water is another remedy. (3) Spraying DDT containing 2 lbs. of 50%w/d DDT in 100 gallons of water may also help to check the pest.

III. PAINTED BUG

Marks of identification : The adult bugs are about one-sixth of an inch long, and are black in colour with red and yellowish markings.

Host plants : Cruciferous plants such as cabbage, raddish, mustard, rape, *sarson,* cress, etc.

Nature of damage : Both nymphs and adults suck the cell sap from the plants. The infested plants finally wear a sickly look and dry up.

Life history : Dark-brown barrel-shaped eggs are laid singly on the leaves and stems and hatch in about a week. On hatching, the nymphs start sucking the sap from the plants and become adults in about three weeks. Often there are a number of generations during a single season. The pest is active from October to March.

Control : (1) Collection of bugs by hand-nets and their destruction is common practice. (2) In the early stages of attack, dusting the crop with 5% BHC at the rate of 15 lbs. per acre may be found effective.

IV. APHID

This group of insects are pests on several crops and in different seasons all over the State. Some species are known to feed on jowar and groundnut in the Kharif season, while those on cabbage, cauliflower and safflower become abundant in the Rabi season. Among the cultivated crops, the following are known to get infested with them: Jowar, maize, groundnut, *wal*, *mung*, *udid*, *bhendi*, *chavali*, beans, lucerne, cotton and *avala* in the Kharif season and cauliflower, cabbage, *knolkhol*, peas, safflower, brinjal, *tondli*, and wheat in the Rabi season. Some fruit trees like the citrus also suffer from certain species of aphids.

Marks of identification : Except for the species feeding on safflower which is black, most of the aphids are generally light green or slightly yellow in colour. They all are very sluggish insects, and do not move much in their wingless stage and generally remain stationary after inserting their minute beaks in the leaf tissue. They are soft-bodied, minute, about one to two mm. in length, and oblong in shape and, due to their stationary habits and small size, they are often confused by laymen as "eggs" of some insects. When found in abundance, scores or more may be found on the under-surfaces of leaves. In the case of jowar, they may be common in whorls also. On microscopic examination, one can observe two tubes arising out of the latter half of their body. These are called cornicles. They are mostly wingless but later in the season or at the maturity of the crop, winged adults are also found. Their wings are transparent sometimes with black lines on them, and are retained in a roof-like position.

Nature of damage : The aphids have a sucking type of mouth parts in the form of a beak whose inside part they insert into the leaf tissue and suck the cell sap. The presence of a number of aphids which generally remain on the under-surfaces of leaves and their continued feeding lead to the general yellowing of leaves and subsequent drying. As they take an excessive amount of cell sap, they also excrete a large amount of sugary solution which comes to lie on the leaf surface. On this sugary solution develop black sooty moulds which blacken the surface of the leaf on which the pest feeds. This is frequently seen on the infested leaves. The sooty mould is not parasitic on the plant but remains as a saprophyte

on the surface but its presence in excessive amounts interferes with the photosynthetic activity of the plant.

These insects are known to transmit virus diseases of certain crops like cardamom and papaya, which may also cause symptoms of the disease.

Life history : In Maharashtra State, the pest does not reproduce by laying eggs, but mature winged and wingless individuals lay young ones. All the individuals normally seen are the females, while the males are not very common or are almost absent in our climatic conditions. Each female can produce scores of individuals. The young ones develop into mature females and thus continue the life-cycle. The rate of reproduction is very rapid and the pest increases in abundance within a few weeks, resulting in the presence of hundreds of these small greenish and roundish individuals appearing on the under-surfaces of leaves. At the end of the season as the crop approaches maturity, winged individuals appear from the wingless ones and they migrate to other crops to continue their life-cycle.

Very often, red ants appear on the plants infested with aphids. These ants come to feed on the sugary solution excreted by aphids. In return they protect the aphids. The presence of ants themselves generally does not cause damage to the plants, but by their habit of protecting and encouraging the aphids, they are indirectly harmful. Hence getting rid of these ants tends to discourage aphid population, though it will not prevent the presence of the aphids entirely.

Control measures : This pest can be successfully controlled by using any of the following insecticides. (1) 40% nicotine sulphate under various trade names is readily available in the market. It is to be diluted at the rate of 1 part in 800 parts of water and about 3 to 4 lbs. of soap are dissolved in the mixture for enhancing its effect. About 80 to 100 gallons per acre are necessary. This application of the spray may be repeated if necessary at an interval of 7 to 10 days. (2) Tobacco decoction may be used. It is prepared by soaking overnight

1 lb. of tobacco waste *Dhus* of good quality in a gallon of water and is subsequently boiled for an hour. When the liquid is boiling, half a pound of bar soap should be added and, after it is dissolved, the resultant liquid should be strained through a cloth and allowed to cool. It may be stocked in this form until required for use. For spraying, the liquid is diluted with 6 to 8 times its volume of water. About 80 to 100 gallons of the diluted decoction are required per acre. If necessary the treatment may be repeated after a period of 10 days. (3) Fish oil rosin soap is also used. Half a lb. of fish oil rosin soap is dissolved in 4 gallons of water. The solution is stirred vigorously till a good lather appears. About 80 to 100 gallons of spray are required for one acre. (4) Pyrethrum extract is another agent commonly used. A concentrated form of pyrethrum flowers sold under various trade names is also used as spray against aphids after diluting one part of it in 1,000 parts of water. About 80 to 100 gallons per acre may be required, depending on the stage of development of the crop.

PESTS OF CHILLIES

Chilli crop in Maharashtra State generally suffers from only one important insect pest—the chilli thrips. As a result of thrips injury, the leaves curl up and symptoms locally known as *"murda"* appear.

Chilli thrips is the same as the thrips described under cotton and its life-history and the control measures for it are similar to those in regard to the cotton thrips. In an irrigated chilli crop, farmers usually prefer sprays, 0.2% DDT or BHC spray (obtained by 2 lb. of 50% w/d DDT or BHC in 50 gallons of water) is being used. Spraying may be repeated if the infestation reappears. DDT may prove more economical because of its longer residual effect, thus reducing the frequency of sprays. When DDT is used, care should be taken not to spray the crop when ready for being harvested. About 15 days should be allowed to elapse between spraying and harvest. (Please refer to cotton thrips also.)

A PEST ONION

Like chillies, onion crop also suffers from thrips infestation. The species infesting it, however, is different and the symptoms of damages are also distinct. (Fig. 27).

Fig. 27
ONION THRIPS
(Left) Wingless Stage (Right) Winged

Onion thrips scrape the epidermis and then suck the cell sap, as a result of which the leaves show small, white patches. In case of heavy infestation, the leaves are covered over by such small patches, giving a whitish appearance to the whole crop.

Control : The control measures are the same as those for chilli thrips. When the leaves of onion are used as food, care should be taken not to spray the crop near harvest-time. A period of two or three weeks should be allowed to elapse before the crop is marketed, particularly if DDT has been used.

PESTS OF CUCURBITS

Such common vegetables as the ridge gourd, bottle gourd, cucumber, etc., have certain pests common to them. But they are not equally injurious to all. Thus, for example, the fruit-fly is the most serious pest of *tondli*, while the other curcurbits are not as attractive hosts. Similarly, Epilachna is common on *kareli*, but is not of much significance in the case of some other vegetables. This fact must always be borne in mind while dealing with pests of cucurbits and their control. They are : (i) the red and black pumpkin, (ii) the fruit

fly, (iii) the Epilachna beetle, (iv) aphids, and (v) the banded blister beetle.

Even after DDT and BHC have become common insecticides, the control of cucurbit pests has not become easy ; this is so because the new halogenated insecticides are highly toxic to cucurbit plants, and, therefore, cannot be used for control of pests on these crops. It is most important to remember that DDT and BHC in any form should not be used for treating cucurbits.

I. RED AND BLACK PUMPKIN BEETLE

Marks of identification : The beetles are red or black coloured and about a third of an inch long. The grubs are small and yellowish white, with a brownish head and, when full-grown, measure about half an inch in length. (Figs. 28 and 29).

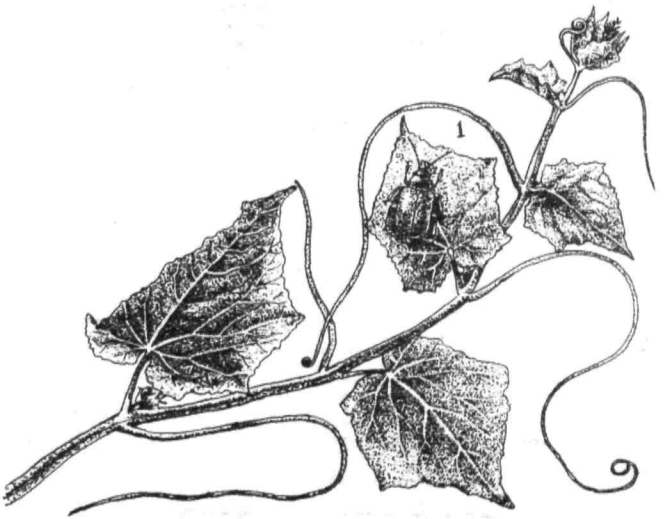

Fig. 28
PUMPKIN BEETLE

Host plants : All cucurbits. The extent of damage differs in the case of different hosts.

Nature of damage : The beetles eat the green part of leaves and thus create irregular holes on their surfaces. The grubs remain in the soil and bore into the roots and stems as well as the fruits which come into contact with the soil. (Fig. 28).

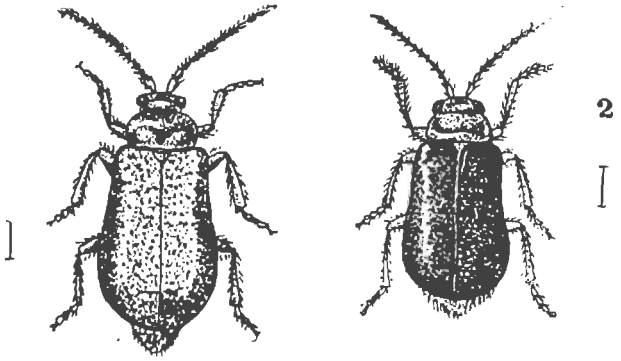

Fig. 29
RED AND BLACK PUMPKIN BEETLES

Life history : Yellowish-brown, elongated eggs are laid in the soil below the plants and they hatch in a period of 6 to 15 days. On hatching, the grubs feed on young roots of plants and become full-grown in 2 to 3 weeks. The total period of their life-cycle is 4 to 7 weeks There are 3 to 5 generations in a season. The pest partially hibernates in winter in the adult stage and is active from March to October but in winter also it causes some injury, which is noticeable.

Control measures : (1) Collection of beetles by hand and their destruction offer the simplest method. (2) Treating the crop with lead arsenate or calcium arsenate is also found useful. Cryolite, after dilution with two parts of talc, has also given a satisfactory degree of control.

II. FRUIT-FLY

The pest has been treated under guavas.

III. EPILACHNA BEETLE

For this, please refer to pests of potato.

IV. APHID

These have been treated under cruciferous vegetables earlier.

V. BANDED BLISTER BEETLE

Marks of identification : The beetles are black with brown stripes and are about an inch long.

Nature of damage : The beetles feed on pollen and petals of cucurbit flowers. Further details will be found under Bairi.

PESTS OF BHENDI

The principal pests of bhendi are the leaf-hopper, the spotted boll-worm and the aphid. They are discussed under potato, cotton and cruciferous crops, respectively.

PESTS OF TONDLI

The main pests, usually of a serious nature, affecting this crop are the fruit-fly and aphids.

APHIDS

These have been dealt with under cruciferous vegetables earlier.

By M. V. KADAM and G. A. PATEL

CHAPTER XII

PESTS OF OILSEED CROPS

In Maharashtra State, there are several oilseed crops of considerable economic value and importance. Out of these groundnut, sesamum, safflower and castor are the commonest and commercially the most important. These crops are susceptible to a few insect pests which often take a heavy toll. However, much is not known so far about them.

It may be stated that research on these pests except those of safflower has not kept pace with research on others and hence most of the information given here may suffer from a like defect.

SAFFLOWER

This is one of the most important commercial oilseed crops of Maharashtra State. It is grown chiefly in soils ranging from medium black to lighter types and is often grown mixed with wheat or gram. It is taken as a dry crop for its oil. The following insects cause damage to it.

I. APHID

Marks of identification : The aphids are tiny, black, soft-bodied insects, usually found on the lower side of leaves and on tender shoots. Initially, they feed on stems and young shoots.

Nature of damage : They suck the sap from the tender parts of plants and thus reduce the vitality of the plants.

Host plants : Safflower, niger, dahlia, arctotis and calliopsis.

Distribution : These are found throughout Maharashtra State, wherever safflower is grown.

Life history : They are tiny black, soft-bodied insects with a sucking type of mouth parts. They are viviparous and a single apterous female gives birth to 8 to 22 young ones called nymphs per day. The nymphs pass through four moults

before reaching the adult stage. The duration of this life-cycles lasts from 7 to 9 days. During its latter part, some winged individuals are produced in most species of aphids.

Control measures : (1) Spraying the crop with nicotine sulphate in the proportion of 1 oz. of nicotine into 5 gallons of water with 4 ozs. of soap gives a good measure of control. The total quantity of spray required per acre is 40 to 60 gallons at a time. Nearly two to three sprayings at weekly intervals are required during late December or early January. (2) Spraying the crop with pyrocolloid in the proportion of 1 oz. pyrocolloid in 5 gallons of water also gives similar good results. About 40 to 60 gallons of spray are required for an acre.

II. LEAF-EATING CATERPILLAR

Marks of identification : The caterpillars are green when young and then turn darkish brown. A full-grown caterpillar measures about 25 mm. in length. The adult moth is medium-sized and dark brown, and has blackish brown forewings and light brown hind wings, and shining, well-developed legs with prominent tibial spurs.

Nature of damage : During the early stages of the crop, the caterpillars eat the leaf and cause defoliation, thus lowering the vigour of the plants. When the plants become hard, the infestation decreases.

Host plants : Safflower, jute, corepsis and niger.

Distribution : It is found in the North and South Satara, Sholapur, Dharwar, Bijapur and Belgaum districts.

Life history : The female moths lay eggs singly or in clusters on plant parts. The eggs hatch in about 4 days. The larvae, when fresh, are green and subsequently turn darkish brown with stripes on the back. The larval period ranges from 15 to 20 days. Pupation takes place in the soil which lasts for 8 days, after which the insect emerges as an adult moth.

Control measures : (1) Hand-picking of caterpillars and destroying them is a simple device that anyone may adopt. (2) The plants can be dusted with 5% BHC at the rate of 15 to 20 lbs. per acre.

GROUNDNUT

Groundnut is an important oilseed crop of the Deccan. It is grown extensively as a Kharif crop. Besides yielding an edible oil, its kernel forms on important article of diet of some people.

Though a hardy crop, it is vulnerable to attack from several insect pests, the more important of which are the aphids, the podbug, the surface grasshopper, and the termites. It is estimated that the reduction in yield due to these insect pests is about 15% to 20% per year.

I. APHID

Marks of identification : They are small, black, soft-bodied insects to be found on the lower side of leaves. They are inactive.

Nature of damage : It is a very important pest as it reduces the vitality and yield of plants by sucking the sap and also acts as the vector of a serious virus disease commonly known as "Rosette" of groundnut.

Distribution : The pest is of sporadic occurrence in most parts of the State, but in Khandesh it frequently takes the form of epidemic.

Life history : The life-history of this pest is similar to that of safflower aphid, but the species becomes abundant in the Kharif season.

Control measures : The control measures are the same as those for aphids on safflower. 10% BHC dust also gives some relief.

II. POD-SUCKING BUG

Marks of identification : The adults are dull brown, dark-grey and about one-third inch long. (Fig. 30).

Nature of damage : The adults and nymphs infest young pods and suk the juice.

Host plants : Groundnut and sesamum.

Distribution : It is found throughout the State.

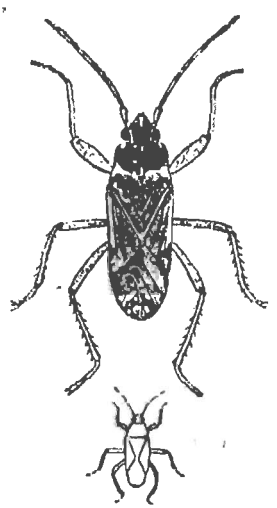

Fig. 30
GROUNDNUT POD BUG

Life history : The eggs are white and laid in the soil. Freshly-hatched nymphs are pink in colour. The total period of their life-cycle is about seven weeks.

Control measures : (1) Before harvest, some rubbish is spread near the threshing yard. The adults come and hide below such heaps of rubbish, which are then destroyed. (2) When the bugs are noticed on the plants, 5% BHC dusting may be tried.

CASTOR

I. CASTOR SEMI-LOOPER

Marks of identification : The moths are stout and have smoky grey or brown forewings, and have dark hind wings with a white band in the middle with 3 to 4 spots near the lower border. A full-grown caterpillar is about 50 to 60 mm. long, slender, and is a semi-looper with the first pair of prolegs reduced. Its colour is variable but usually grey or black with reddish or whitish side stripes. (Fig. 31).

Nature of damage : The caterpillars feed on the leaves of plants from the lower side only, leaving out the veins.

Host plants : Castor and pomegranate.

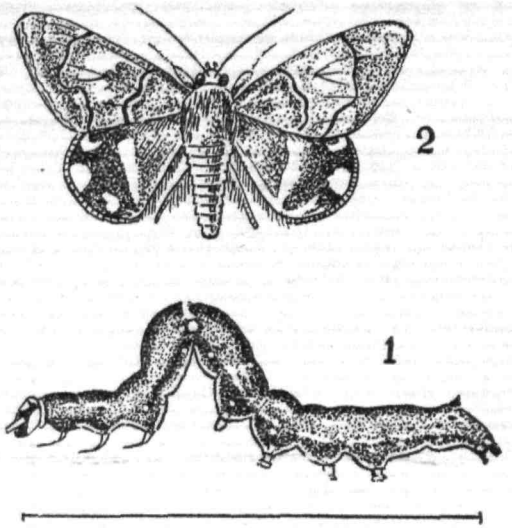

Fig. 31
CASTOR SEMI-LOOPER
1. Caterpillar 2. Moth

Distribution : It is found throughout the castor-growing areas of Maharashtra State.

Life history : The eggs are laid singly scattered over the lower surface of leaves of the food plant. The egg-laying period is 2 to 3 days, and the larval period about two weeks. Pupation takes place in the dried leaves lying on the soil in cocoons and the pupal period is 10 to 12 days. The pest hibernates as pupae in winter and is active from June to October.

Control measures : (1) Open spaces are prepared in the infested fields where the birds can rest freely and attack caterpillars. (2) The pupae are exposed by thorough ploughing after harvesting the crop. (3) Dusting with 5% BHC at the rate of 15 lbs. to 20 lbs. per acre is also quite effective. The leaves of such dusted crop should not be immediately used for feeding silk worms.

II. CASTOR CAPSULE-BORER

Marks of identification : The moth is small and bright yellow in colour, and has numerous black dots. The full-grown caterpillar measures about an inch long and is brownish with a pinkish tinge with some spiny warts.

Nature of damage : The caterpillars bore the stem and fruit and destroy them. The presence of the pest can be made out by the black mass of excreta on the capsule.

Host plants : Stems and seed-capsules of castor, fruits of guava, stems of turmeric, and rhizomes and stems of ginger are frequently infested by this caterpillar.

Distribution : The pest occurs throughout the castor-growing area in the State.

Life history : The eggs which are laid by the female moth on the capsules and shoots hatch after six days and the larva bores into the stem or capsule and when full-fed, pupates inside a white silken cocoon in the stem or the capsule. The total period of their life-cycle takes about four to five weeks but it lasts longer in winter.

Control measures : Only cultural methods are known to have been tried so far. Chemical measures have not yet been worked out. Removing and burning all early-attacked capsules and shoots help to reduce the degree of infestation.

SESAMUM

The pests of sesamum are the gall fly, the sphinx-caterpillar, and the pod-sucking bug.

I. GALL FLY

Marks of identification : The adult is like a small delicate mosquito, while the larval stage is legless and the larva remains inside the gall.

Nature of damage : The maggots are found inside the young flower buds and the irritation causes gall formation and interferes with the process of pod formation. Consequently, the bud withers without bearing fruit.

Host plants : So far no other host plants are known except sesamum.

Distribution : The pest is found in most parts of the State.

Life history : It is a specific pest of sesamum and is not yet observed on other crops. The eggs are laid on flowers and the maggots feed on the contents of the flower and then develop into pupae. They emerge as adults which resemble mosquitoes.

Control measures : Insecticidal measures are not worked out yet. Hence, we have to resort to preventive measures. These are : No stray plants should be allowed to grow in the off-season so as to avoid giving rise to conditions favourable to the breeding of this pest, and all infested buds should be scrupulously clipped and destroyed.

II. SPHINX MOTH

Marks of identification : The moth is large with a dark-grey, bluish thorax. The abdomen is yellow with black bands. The forewings are dark-brown. The full-fed larva is 90 mm. long and stout, with a rough skin and with an anal horn at the abdominal end. It is light greenish in colour and has eight yellow stripes on its body. (Fig. 32).

Nature of damage : The caterpillar feeds extensively on leaves.

Distribution : The pest is found in all til-growing tracts of Maharashtra State.

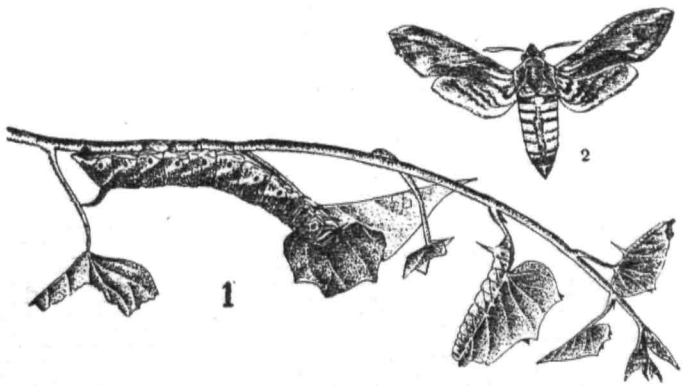

Fig. 32
SPHINX MOTH
1. Caterpillar 2. Moth

Life history : The eggs are laid singly on leaves. The larval period is about two months. Pupation takes place in the soil and the pupal period lasts about a month and a half.

Control measures : (1) As the caterpillar is very large, hand-picking can be practised with success. (2) Dusting with 5% BHC may also be effective.

III. POD-SUCKING BUG

This pest has been dealt with in detail under pests of groundnut.

By H. V. KATARKI and K. S. GORE

CHAPTER XIII

PESTS OF FIBRE CROPS

Fibre crops in many cases yield high cash profits to farmers. Amongst them cotton occupies the foremost position. Though many of the inndigenous varieties of cotton are resistant to insect damage, such notorious pests as the spotted boll worm cause serious losses if they are not constantly kept under control by the usual practice of uprooting the stalks after harvest. While, on the other hand, the problem of insect infestation on the new long-staple cotton is of such a serious nature that a successful crop is rarely possible without proper insecticidal measures.

Many of the other fibre crops are not, as a rule, very paying to cultivate ; hence the farmer may not like to take up their cultivation and may not care to control the pests; nevertheless, when insect epidemics threaten to cut down yields very severely, control measures will of necessity have to be undertaken. Information on insect pest control of the other fibre crops except cotton is relatively meagre, and hence, besides cotton, an account of pests affecting sannhemp and ambadi only is included here. It is hoped that the same will be of considerable value to growers in times of serious epidemics.

COTTON

I. SPOTTED BOLL WORM

Marks of identification : There are two species of the spotted boll worm—the adults of one species have pale white upper wings with a broad greenish band in the middle ***(Earias tabia)***, while the adults of the other species have completely green upper wings ***(Earias insulana)***. The caterpillars of both species are brownish white and have a dark head and a prothoracic shield. They have a number of black and brown spots on the body and hence the name spotten boll worm. A full-fed larva measures about three-quarters of an inch. (Fig. 33 and Plate I, figs. 1 and 3).

Nature of damage : In the beginning of the cotton season, the caterpillars bore into the growing shoots of the plant. When the flower buds appear, the larvae are found boring

into them and later in bolls which show holes plugged with excreta. The infested buds and bolls are mostly shed, but if they remain on the plant, they open prematurely. Consequently, lint from such bolls fetches a smaller price in the market.

Host plants : Bhendi, ambadi, shoe flower and hollyhock.

Distribution : This pest is met with all over Maharashtra State and some other parts of India.

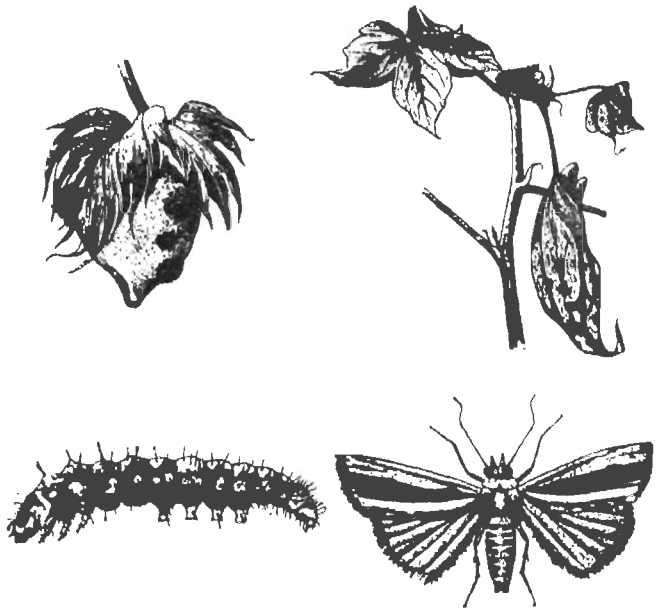

Fig. 33
SPOTTED BOLL WORM
(Top) Attacked Boll and Shoot (Bottom) Larva and Moth

Life history : Each female lays about 200-400 eggs singly on flower buds, bracts, bolls, etc. The egg period is 4 to 7 days. The larval period varies from 9 to 16 days, depending on the climate. The full-fed larva pupates in a silken cocoon outside the bolls in which stage it remains for 8 to 14 days. The total period of their life cycle, on an average, is about 22 to 35 days. The pest is active practically throughout the year and there are several generations annually.

Control measures : The pest being an internal feeder, only preventive methods are feasible. Immediately after harvesting the crop, the stubbles should be removed and destroyed, so as to prevent breeding of the pest in the off season. Such operations, if performed collectively, will decrease the carry-over of the pest to the growing season and thus decrease damage to the regular crop. The uprooting of stubbles can be done by special plant-pullers devised by the Agricultural Department. The clipping and destruction of the initially infested top shoots should be promptly attended to in the earlier stages of the crop. All malvaceous weeds also should be destroyed during the off season, as otherwise they will harbour the pest and carry it over to the next crop. Summer bhendi should be avoided in affected areas.

II. PINK BOLL WORM

Marks of identification : The moth is about half an inch across wings and is dark brown in colour. The first segment of the antenna has five to six stiff hours and the palpa are long and curved upwards. Caterpillars when full-fed measure ¾" long and are pink in colour with a brown head. (Fig. 34).

Distribution : This pest is ubiquitous, since it is found all over Maharashtra State and other parts of India and the world.

Host plants : Cotton, ambadi and other malvaceous plants.

Nature of damage : The caterpillars feed inside the bolls and make them drop down. The pest is more destructive to American cottons than to indigenous varieties. As the caterpillars enter the bolls, their entry holes are closed and it becomes difficult to spot out the affected bolls until they decay and fall to the ground. Unlike the spotted boll worms, the caterpillars never attack shoots.

Life history : The female lays eggs singly on leaves, buds, flowers and bolls. The eggs hatch in 4 to 7 days and the caterpillars, on hatching, feed on developing flowers, seed or lint. The larval period is about 3 to 4 weeks, but some of them remain dormant for long or resting ; there are caterpillars which may remain in this state as long as two-and-a-half years. Pupation generally takes place inside the boll, often

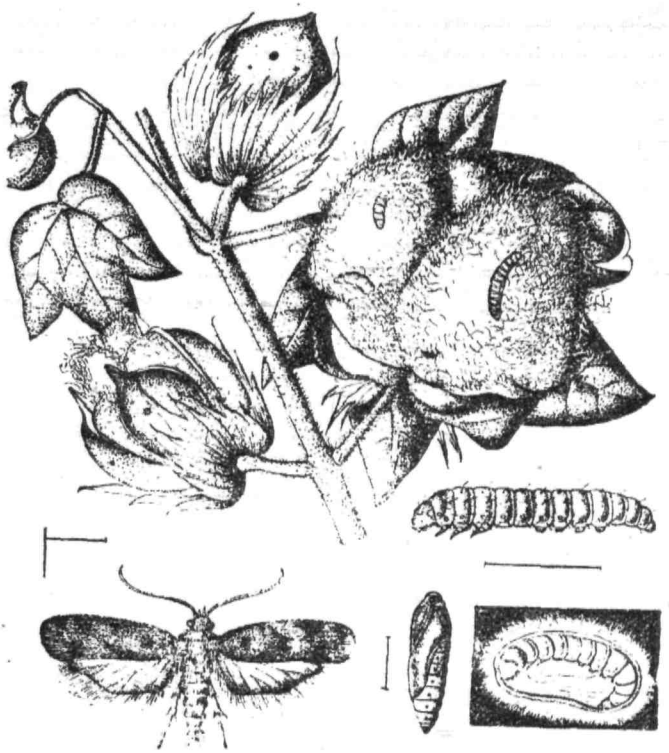

Fig. 34
COTTON PINK BOLL WORM
(Top) Infested Bolls (Right) Caterpillar (Bottom) Moth (Right) Pupa and hibernating larva

in that portion of the seed hollowed by the feeding of larvae or in the soil. The pupa is enclosed in a silken cocoon and the moth emerges after about 10 days. The pest is active from July to December, while the winter season is passed in the larval stage, in which it remains curled up in a small cocoon in stored seed in soil, or in bolls in the field. The larvae develop further when the moisture is adequate and later a fresh brood infests the new crop.

Control measures : Like the spotted boll worm, remedial measures for the pest are largely of a preventive nature. The pest is brought to new areas along with infested seeds, wherein the larva remains dormant until favourable conditions

obtain. Therefore, before sowing, the cotton seeds should be got fumigated with carbon disulphide at the rate of 1 oz. to 15 c. ft. or heating the seed to 145°F without injury to the seed. As a further measure to check the pest, the early-infested and shed bolls should be promptly picked up and destroyed.

III. COTTON JASSID

Marks of identification : The adult is wedge-shaped, about 2 mm. long and pale green in colour. The front wings have a black spot on their posterior parts. The nymphs are wingless, also pale green in colour and are found in large numbers on the lower surface of leaves. They have a characteristic way of quickly walking diagonally in relation to their body. (Fig. 35).

Distribution : This occurs in many parts of the Indian Union, including Maharashtra State.

Host plant : Cotton, bhendi, brinjal, potato, hollyhock.

Nature of damage : The nymphs and adults pierce the plant tissues and suck the cell sap by their special type of mouth parts. Initial damage is noticed by the yellowing of the margins of leaves, while a continued excessive infestation may result in etiolation of the leaves and subsequent drying up and stunted growth of plants.

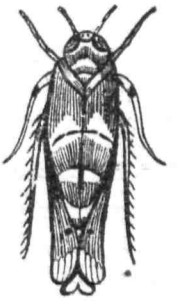

Fig. 35
COTTON LEAF HOPPER

Life history : The adult female lays about 30 eggs in the tissue of the leaf-vein and minute nymphs, on emerging out of the eggs, start feeding on leaves by sucking the cell sap. The egg stage is completed in four to eleven days, the

nymphs moult five times. Their entire life cycle is completed in two to four weeks. The pest is active particularly during the monsoon season and, if adequate precautions are not taken, severe losses result.

Control measures : 5% DDT dust at the rate of 15 to 20 lbs. per acre is known to be effective. However, the use of DDT alone should be discouraged, as many times it leads to excessive increase in aphid or mite population. To prevent this, it is necessary that 5% DDT be mixed with an equal quantity of sulphur before dusting. This insecticide, which is sold ready-made, gives a good measure of protection for about two weeks if rainy weather does not follow the dusting operation. DDT sulphur mixture should not be used for Indian or Asiatic cottons, as sulphur scorches these varieties severely. On Asiatic cottons, however, jassid infestation is less, due to their relative resistance to jassid attack. If, however, infestation appears, 5% DDT alone should be used on such varieties. The DDT and sulphur mixture is only safe on the American varieties of cotton, which are also more prone to jassid infestation.

IV. COTTON THRIPS

Marks of identification : The adults are minute, delicate insects, less than 1 mm. long and are light yellow in colour. On microscopic examination, their wings can be observed to have a fringe of hair throughout and hence they are also sometimes called fringe-winged insects. The younger stages are still more minute but wingless. These adults and nymphs are found in hundreds, mostly on the lower side of leaves, but they are also found to feed on the upper surfaces. (Plate I, figs. 4 and 5).

Nature of damage : These insects have such a type of mouth-parts that they can scrape the epidermis of leaves and are then able to suck the oozing cell sap. The plant tissue in the region where the insect has fed dries up and initially becomes whitish but later often turns brown. The symptoms of brown patches may also appear on bolls. These are the characteristic symptoms of thrip injury. Excessive feeding may also lead to curling of leaves and stunted growth of the whole plant, as is commonly seen in a chilli crop.

Host plants : Cotton, chillies, mango, tondli, bottlegourd

and guava. It is a serious pest of American cottons and the same species also infests chillies severely.

Distribution : The pest is encountered throughout Bombay State as also in many other parts of the Indian Union.

Life history : The adult female insect can lay eggs after or before being fertilized by the male. The eggs are pushed into the leaf tissue, generally on the lower side of the leaf, where the insect is mostly found. The nymphal stage is very short and passes through four stages (or instars) and then attains the adult stage. The egg stage lasts four to five days, the nymphal stage is completed in two to five days and the adult insect which lives for 10 to 25 days can lay 30 to 50 eggs during its life-time.

The insect is particularly active during the latter part of the monsoon and, since continuous rain seems to wash away the insects, a dry spell appears necessary for its growth. The pest has been noted to become serious in the months of September and October in most places, but in the canal areas of the Deccan, it is known to become abundant in August also.

Control measures : The pest can be easily controlled by DDT, BHC or nicotine sulphate. All these have proved to be effective, but DDT should be preferred for its residual effect and its toxicity to jassids. As in the case of the control of jassids, 5% DDT should be used in admixture with sulphur in the proportion of 1 : 1. If the insect population is found to increase after some time, dusting may have to be repeated at an interval of a fortnight. DDT sulphur mixture, as pointed out earlier, should not be used for Asiatic cottons but is safe for the American varieties. Nicotine sulphate can be used at 1 part in 600 parts of water with 4 lbs. o fsoap. However, it is more cumbersome and has a shorter residual effect than DDT.

V. COTTON APHID

Marks of identification : The adult is oblong, about 1 mm. long, dark yellowish green or black in colour and has two projections called cornicles on the dorsal side of the abdomen. It is mostly found in a wingless stage. (Fig. 36 and Plate I, fig. 10-12).

Nature of damage : These insects push their beaks into the plant tissues in order to suck the cell sap and remain in this position for long periods. The damage caused by these insects is somewhat similar to that caused by cotton jassids.

Host plants : Cotton, bhendi, potato, chilli, brinjal and water-melon.

Distribution : The pest is met with in all cotton-growing areas of Maharashtra State.

Life history : The alate and apterous forms reproduce parthenogenetically and viviparously. A single apterous female gives rise to 8 to 22 young ones per day called nymphs.

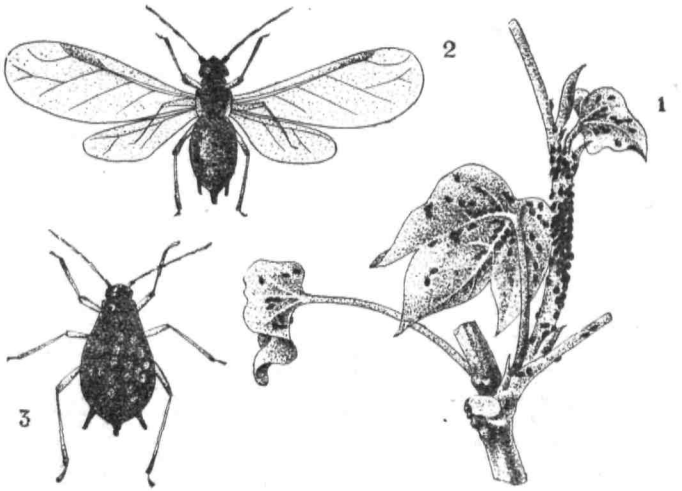

Fig. 36
APHIDS
1. Aphids on twig 2. Winged Aphid. 3. Wingless Aphid

They pass through four moults before reaching the adult stage. The duration of the life-cycle varies from 7 to 9 days.

Control measures : (1) Spraying with nicotine sulphate at the rate of 1 lb. in 80 gallons of water with 5 lbs. of soap is quite effective. (2) Spraying with pyrocolloid in the proportion of one part in 1000 parts of water also gives satisfactory results. (3) Spraying with fish oil rosin soap at the rate of 8

ozs. in 4 gallons of water is often restorted to. Nearly 80 to 100 gallons of spray are required per acre in each case. For control of aphids, DDT should be avoided, as it may not only not kill them but may also lead to their increase. BHC is somewhat effective but the kill obtained is less than that with such compounds as nicotine sulphate and pyrocolloid.

VI. COTTON LEAF ROLLER

Marks of identification : The moth is medium-sized, having yellowish wings with brown waxy markings. The caterpillars when full-grown measures an inch long and has a glistening green colour with the head and prothorax dark. (Plate 1, figs. 8 and 9).

Nature of damage : The caterpillars roll up the leaves, which then resemble funnels and feed from the margin while remaining hidden. Thus, by and by the entire leaf is eaten up.

Host plants : Cotton, bhendi, and other malvaceous plants. The pest only occasionally assumes serious proportions. Tall and bushy American varieties are more susceptible to attack from it.

Distribution : This pest occurs throughout Maharashtra State.

Life history : The mother moth lays smooth, flat white eggs singly on tender leaves, usually on their lower surface. The egg-period lasts six to seven days, while the larval stage takes up 15 to 20 days. The full-fed larva pupates inside the cocoon in the rolled up leaf and remains in the stage for six to seven days. The total period of its life-cycle is about four weeks.

During winter, the full-grown caterpillar hibernates in plant debris which are webbed together. Damp and cloudy weather favours the growth of this pest.

Control measures : (1) Removal and burning of all rolled-up leaves containing the caterpillars is the simplest device of control. (2) If the infestation is heavy, the crop be dusted with 5% BHC or 5% DDT.

VII. RED COTTON BUG

Marks of identification : The adult is about half an inch long. Its general colour is bright red, with eyes, scutelum and antenna coloured black. A series of white transverse bands is present on the ventral side of their abdomen. The nymphs resemble the adults in colour but are wingless.

Nature of damage : The adults and nymphs suck the plant-sap and greatly impair its vitality. In addition, they also feed on the seeds and lower their oil content. Due to the excreta of these insects, the lint is soiled. The infested seeds are useless for sowing.

Host plants : Cotton, bhendi, Deccan hemp and hollyhock. On the whole, it is a minor pest.

Distribution : It occurs throughout Maharashtra State.

Life history : The female lays round and bright yellow eggs in a mass on the soil near the plant. The eggs hatch in six to seven days. The nymphs, which are bright red, pass through six instars in 30 to 35 days before reaching the adult stage. The total period of their life-cycle is about six to eight weeks but in winter, the pest hibernates in the adult stage.

Control measures : (1) The adults and nymphs can be collected in large numbers by shaking them in a tray containing a little kerosene oil added to ordinary water. (2) In case the pest becomes serious, which rarely happens, it may be treated with 5% BHC.

VIII. DUSKY COTTON BUG

Marks of identification : The adults are small in size and dusky-coloured, about a quarter of an inch long. The nymphs, after the first moult, become reddish brown and their colour darkness after each moult, ultimately becoming dusky. (Plate I, figs. 6 and 7).

Nature of damage : The adults and nymphs are found feeding on open bolls and also on those bolls that are damaged by boll worms. They also feed on flowers.

Host plants : Cotton, bhendi, hollyhok and Deccan hemp, The pest is only occasionally serious.

Distribution: It is found throughout Maharashtra State.

Life history: Cigar-shaped eggs are laid in the lint close to the seeds in batches of six to 10. The egg-period is about five to six days. The nymphal state lasts about two weeks during which the nymphs moult six times, after which fully-winged adults emerge. The activity of the pest is from November to February.

Control measures: (1) The bolls are shaken in a vessel containing kerosenised water and (2) in case of heavy infestation 5% BHC dust is used.

SANN-HEMP

I. HAIRY CATERPILLAR

Marks of identification : (i) *Utetheisa pulchella*—The moth is of a pale white colour, with red and black dots on its upper wing. The hind wings are white with black patches on them. (ii) *Argina cribraria*—the head and thorax of the moth are orange-yellow, with black spots ringed with yellow. The hind wings are orange, with black spots on them. (iii) *Argina syringa*—The moth has a pink-brown head and prothorax, with black spots ringed with yellow on them. The hind wings are crimson with black spots.

The full-grown caterpillar is one and a half inches long, white black lines along the sides and irregular black patches with yellow lines. There is an orange spot on each segment. Its body which is whitish (except the head) has black hair all over it.

Nature of damage: The caterpillars feed on leaves and occasionally also bore into the seed capsule.

Host plants: The pest is only occasionally serious on sann-hemp and other leguminous plants.

Distribution: This kind of caterpillar occurs throughout the State of Maharashtra.

Life history: The eggs are laid singly or in batches on the underside of leaves and they hatch in three or four days; the larval period lasts for about two weeks. The full-grown larva enters the soil for pupation in which state it continues for five to six days. Its life-cycle is four weeks. The pest is active from April to November and thereafter it hibernates as pupa in the soil.

Control measures: (1) Clean cultivation assists control. (2) In the early stages, handpicking may be effective. (3) Very satisfactory methods of control are not yet available. However for young crops 5% BHC or DDT poison baits at the rate of 15 to 20 lbs. per acre may be tried. Dusting the crop with 10% BHC also gives some control but the result is not very satisfactory.

II. FLEA BEETLE

Marks of identification : Many species of the flea beetle are known to exist. Some are serious pests of jowar and wheat. They are all small, about one-tenth of an inch long, and are provided with thickened hind legs, which enable them to jump. Hence the name flea beetle. Mostly they are blackish in colour, while some species are brownish.

Nature of damage: The beetles bite small holes in the leaves of the plant.

Distribution: This beetle is found throughout Maharashtra State and is a minor pest, but occasionally it may cause serious damage.

Life history: Though this has not been worked out in detail, it is known that their eggs are usually laid on soil surfaces and the larvae feed on the roots of cultivated and wild host plants. Most of the species become abundant in the Kharif season.

Control measures: The relative merits of the various insecticides have not yet been worked out, but dusting with 5% BHC at the rate of 15 to 20 lbs. per acre may be tried with expectation of a fair measure of success.

III. STEM-BORER

Marks of identification : The moth is greyish-brown in colour and the caterpillar is about a quarter of an inch long and smooth. The head and prothorax are dark while the rest of the body is pale white. The colour changes to pinkish as the larva grows up.

Nature of damage: The caterpillar borrows into the stem near the nodes and causes small gall-like swellings on the infested shoots.

Distribution: It is rarely serious but is found throughout Maharashtra State as a comparatively minor pest.

Control measures: Being an internal feeder, insecticidal measures may not be of much use. We have, therefore, to depend on preventive measures such as removal of the affected shoots. The pest has not been studied in any great detail so far and the control measures have not been worked out.

IV. CAPSID BUG

Marks of identification : The adult is a small, active, greenish bug.

Nature of damage: The insects appear in numbers and suck up the plant juice, giving the plants a pale and faded appearance.

Distribution: This pest occurs throughout the State, but only as a minor pest.

Life history : The eggs are laid in tender tissues. They are white and cylindrical Nymphs in different stages of development are found on the plant and they all suck up the plant juice.

Control measures: The life history and control measures have not been worked out so far. However, 5% DDT or BHC must be tried, if the pest becomes abundant.

AMBADI

The two pests which commonly infest this crop are jassids and aphids. The details of control measures for these pests are the same as those in the case of cotton jassids and cotton aphides given elsewhere in this book.

By G. A. PATEL, H. V. KATARKI and N. G. PATEL

CHAPTER XIV

PESTS OF TOBACCO AND BETELVINE

It is often thought that plants containing poisonous alkaloids are not infested by insects and it sounds paradoxical to discuss insect pests infesting tobacco, the source of nicotine used for insect control. Though this is not so, the truth underlying the paradox will be abundantly clear from the number of pests that infest tobacco. Among the various pests attacking tobacco are: (i) The tobacco leaf-eating caterpillar, (ii) the stem-borer, (iii) the cut worm, (iv) the surface grasshopper, (v) the white fly, and (vi) the aphid. The life-history and control measures of some of these are discussed hereafter.

I. TOBACCO LEAF-EATING CATERPILLAR

Marks of identification : *The moths are medium-sized and stout-bodied, with front wings pale grey to dark brown in colour having wavy white markings and whitish hind wings. The caterpillars are pale greenish-brown and smooth, with dark markings and a prothoracic plate and are about one and a half inches long when full grown. (Fig. 37).*

Nature of damage: The caterpillars, when young, feed gregariously on tender leaves and juicy stems at night and become isolated at the later stages of growth.

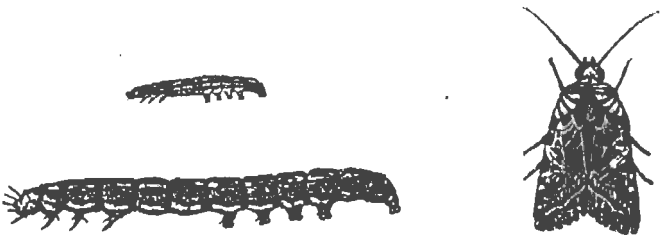

Fig. 37
THE TOBACCO CATERPILLAR
(LEFT) Larva (RIGHT) Moth

Host plants: Tobacco, pest, brinjal, tomato, castor, banana, agathi, are the main hosts.

Life history: Numerous eggs are laid in masses covered with brown hairs on tender leaves and they hatch in a period

of four to five days. The caterpillars, which are darkish in appearance, on hatching, start feeding on the soft green layers of leaves gregariously during the night, both in seed-beds and planted fields. They become isolated when full grown in about two to three weeks and descend to the ground and pupate in rough earthen cocoons. Their pupal period lasts from nine to fourteen days and the total period of their life-cycle is 30 to 40 days.

Control measures: Preventive measures such as collection and destruction of egg-masses and caterpillars and thorough ploughing after the harvest of the crop to expose pupae may be launched with a fair degree of effectiveness.

Insecticidal measures include dusting with calcium arsenate at the rate of ten to fifteen lbs. per acre.

II. STEM-BORER

Marks of identification : The moths are small, active, pale-brown closely allied to the potato tuber moth. The catepillars are small and brownish white in colour with a dark head and are about half an inch long when full-grown.

Nature of damage: The caterpillars bore into stems and cause characteristic gall-like swellings on them.

Life history: Elongated eggs are laid on leaf-stalks and the lower side of leaves of tobacco plant and they hatch in about six to seven days. Tiny caterpillars on hatching, burrow along the leaf-stalks into the stems and feed on the internal tissues. The irritations caused inside the stems by larvae create gall-like swellings on them. The caterpillars become full-grown in about six to seven weeks' time and pupate inside the larval burrows. Their pupal period lasts about 10 days and the total period of their life-cycle is seven to eight weeks.

Control measures: Preventive measures include the removal and destruction of the affected stems during the growth of the crop and also after harvesting the crop. Stray and wild tobacco plants should be destroyed. Care should be taken to plant healthy seedlings from the seed-bed if infestation is noticed at the seedling stage.

III. CUT WORM

This pest has been discussed under pests of potato.

IV. SURFACE GRASSHOPPER

For details see the chapter on pests of jowar

V. WHITE FLY

This pest has been treated of under citrus.

VI. APHID

This pest has been discussed in detail under safflower, cotton and vegetables.

PESTS OF BETELVINE

BETELVINE BUG

Marks of identification : The adult bugs are dark red or reddish brown, with a dark head and antennae. They measure approximately 6.5 x 2.3 mm. The female bugs are relatively larger than the male bugs. Newly-emerged nymphs measure roughly 3.6 x 0.41 mm. and they are red when young and reddish-brown when full-grown.

Nature of damage: Both nymphs and adults suck the juice from tender leaves by puncturing the tender tissues. Feeding is generally done in between veins which results in producing dark, angular patches on the leaves.

Host plants: Betelvine and ghod vel (*Vitis latifolio*).

Life history: Elongated, stalked and slightly curved eggs are inserted singly in the tissues of tender stems, which can be located by their stalks jutting out. The eggs hatch in about 16 days during January-February and in eight days during April-May. Newly-emerged nymphs start sucking the juice from the tender leaves by puncturing the tender tissues and transform themselves into adults in a period of 18 days in January-February and in 12 days in April-May after passing through five months. These reddish-brown adult bugs shun light and usually take shelter under bent leaves. When disturbed, they readily fly away, while the nymphs drop to

the ground. The warm and humid weather prevailing from June to October favours rapid multiplication of this pest, whereas its activity is slowest during the cold months of December and January.

Control measures: This pest can be successfully controlled by spraying the affected crop with nicotine sulphate or pyrocolloid in the proportion of 1 lb. in 80 gallons of water. About 100 to 120 gallons of the spray may be used per acre. Successive sprayings should be given after an interval of about two weeks. In recent times, water dispersible DDT (about 0.2% spray obtained by taking 1 lb. of 50% w/d DDT in 25 gallons) is being used extensively. Precaution is, however, necessary to see that the leaves are thouroughly cleaned before eating or to spray the crop two or three weeks before harvesting it.

By M. V. KADAM and G. A. PATEL

CHAPTER XV

PESTS OF FRUIT CROPS

There are some crops whose cultivation brings a cash return to cultivators. Among them is fruit cultivation. Hence some fruit crops like the mango and citrus have often attracted the attention of enterprising farmers. Fruit tree cultivation is nevertheless a somewhat specialized branch and in it problems arise which are peculiar to it. This specialized nature of fruit cultivation is particularly to be seen in the need for protecting the orchard from insect pests. The problems are not very difficult and because their proper handling minimises the danger of considerable financial loss, the orchardist is always keen to adopt remedial measures, even though they mean an extra expenditure. That this has been the case is abundantly clear from the large quantities of insecticides now being consumed for pests like the mango hopper and mites in our State.

The intelligent farmer, even though he has been controlling the pest for a number of years, is often not aware of the detailed nature of the problem he has been handling. For his benefit and for those who are making attempts to control pests of fruit crops, the following information should prove of value.

CITRUS

There are a number of pests on citrus trees some of which are important in our State. They are (i) the lemon butterfly, (ii) the white fly, (iii) the aphid, (iv) the leaf miner, (v) the fruit-sucking moth (vi) red ants, (vii) the mealy bug and scale insects and (viii) citrus mites. Not all these are present in epidemic form everywhere in the State. The main problems in the Deccan the aphids, mites, the lemon butterfly and the fruit-sucking moth call for considerable attention at various places. The leaf miner is present nearly everywhere, while the others are generally minor pests but may become abundant occasionally. Their life history and the necessary control measures for all these pests are detailed below.

I. LEMON BUTTERFLY

Marks of identification : The adult is a beautiful butterfly with yellow and black markings on wings, which have an expense of about 2-2½". (Fig. 38). Its hind wings have a brick-red oval patch near the anal margin and a tail-like extension behind—on account of which it is commonly known as a swallow tail butterfly. The young caterpillar is darkish brown in colour with irregular whitish stains. When full-grown, it turns deep green in colour and cylindrical in form and measures about 1½" in length, with a hump-like appearance in front. (Fig. 39).

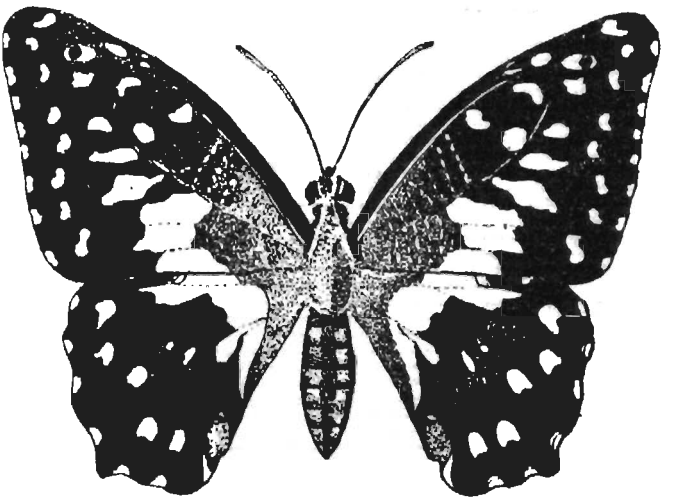

Fig. 38
THE LEMON BUTTERFLY

Host plants: All citrus species and sometimes the other members of the family Rutaceae, to which citrus belongs.

Nature of damage: The caterpillars usually feed on tender leaves right up to the mid-rib and thus defoliate the plants. The pest is not of regular occurrence but occasionally becomes serious, particularly on young seedlings.

Fig. 39
CATERPILLAR OF THE LEMON BUTTERFLY

Life history: The female butterfly deposits small round pale yellow eggs singly on the tender leaves of the plant. They hatch within 3 to 7 days. The freshly emerged larvae start feeding on tender leaves and take about 2 weeks to become full-grown. Later, they pupate on the plant itself and remain attached to it by silken girdles. The pupal period lasts about 2 to 3 months in winter.

Control measures: Treating the affected plants with a stomach poison like calcium arsenate or 5% BHC dust may be tried. Pyrethrum emulsion 1 lb. in 100 gallons may also control the pest.

II. WHITE FLY

Marks of Identification : The adult (Fig. 40) is a minute insect measuring about ½ mm. in length having white or greyish wings, a yellowish body and red medially-constricted eyes. Nymphs and pupae (Fig. 41) are oval-shaped, scale-like, blackish, with marginal bristles like fringes. The nymphs remain stationary once they have settled down. The infested leaf gives a black dotted appearance.

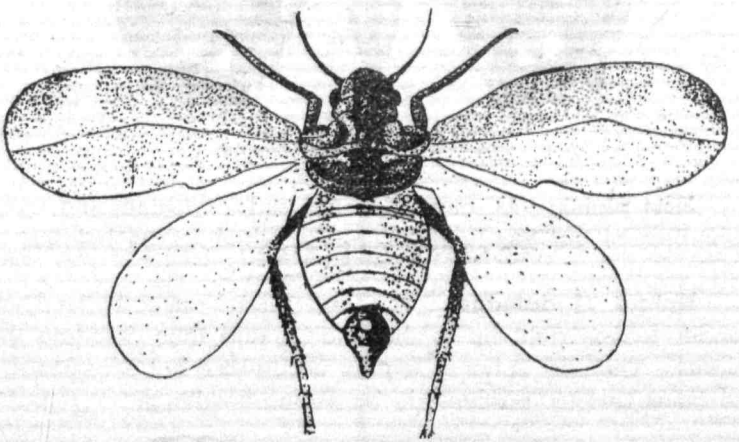

Fig. 40
CITRUS WHITE FLY ADULT

Host plants: There are several species of white flies infesting different varieties of citrus, cotton, coffee, banana, castor and some ornamental plants.

Nature of damage: The damage caused is of two types. Firstly, the nymphs and adults suck the sap from leaves, as a result of which the leaves wither and later turn brownish, and fruit-setting is affected. Secondly, the nymphs secrete a honey-dew which attracts fungus, which in turn gives the tree a blackish appearance. (Fig. 42).

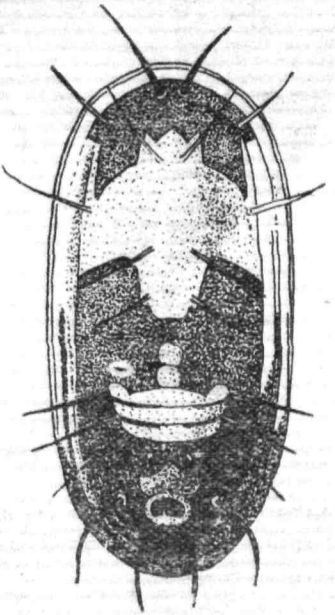

Fig. 41
CITRUS WHITE FLY PUPA
(Greatly enlarged)

Life history: The female white fly lays about 150 to 200 yellowish eggs on the underside of tender leaves. These hatch out in about 10 days. The freshly hatched nymphs crawl about on the leaves till they find a suitable place to settle in. In their early stages, they are called crawlers and nymphs; they become full-fed in about 3 to 10 weeks when they change to oval blackish pupae, whose bodies are margined with fringes or toothlike divisions with the middle part coloured orange-yellow in some species. The pupal period lasts from 16 to 22 weeks.

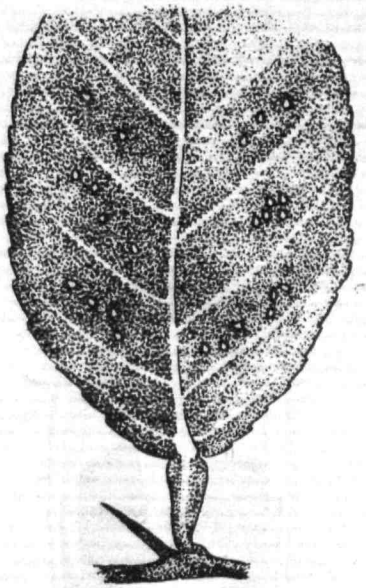

Fig. 42
CITRUS LEAF WITH WHITE FLY INFESTATION

Control measures: The pest can be controlled reasonably well by two applications of a good spray of rosin compound at an interval of a week.

III. CITRUS APHID

Marks of identification : The adult is a minute, oval, dark-brown licelike insect, measuring about 1/16" in length with or without wings and is found in clusters or colonies on tender shoots. It has two short or long tube-like structure called cornicles on the dorsal lateral side of the latter half of the abdomen. These structures are characteristic of aphids.

Host plant : Mainly found on tender leaves and shoots of citrus.

Nature of damage: Both adults and nymphs feed on the sap of growing shoots and leaves. As a result, the leaves become badly curled and at times etiolated. In severe cases of

attack, the vigour of the tree declines and the ripening of the fruit is adversely affected.

Life history: Like all other species of aphids in Maharashtra State, this species reproduces without fertilization and lays young ones and not eggs. In the early part of the season, only those without wings are produced. As the season comes to an end, winged ones appear which migrate to other host plants.

Control measures: Two or three applications of a spray containing 1 lb. nicotine sulphate (40%) and 4 lb. soap in 80 gallons of water given at weekly intervals will control the pest very effectively. Pyrethrum emulsion 1 lb. in 100 gallons or fishoil rosin soap at the rate of 12½ lbs. in 100 gallons of water or tobacco decoction (described elsewhere) can also be used with success. (Also see page 94).

IV. LEAF MINER

Marks of identification : The adult is a tiny silvery white moth with white hind wings measuring 1/4" when expanded and brown striped forewings having a prominent black spot near the tip, both pairs being fringed with hairs. The full-grown caterpillar is slender and yellowish green in colour with brownish mandibles and is found inside the gallery formed in the leaf tissue.

Host plants: Although the larvae prefer to feed on the leaves of varieties of citrus, they are also reported to mine the leaves of jasmine and cinnamon.

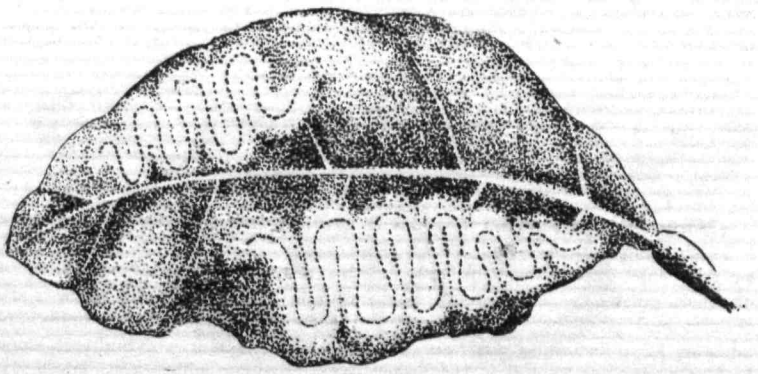

Fig. 43
CITRUS LEAF SHOWING ZIGZAG PATCHES MADE BY CITRUS LEAF MINER

Nature of damage: The larvae mine specially the tender leaves and feed on the inner tissues of leaves, leaving the outer skin layers intact and thus give rise to transparent, zig-zag galleries (Fig. 43) characteristic of miner damage. As a result, the leaves turn pale, curl badly and eventually dry off. The mined leaves are also suspected of aiding infection by bacteria which cause citrus canker. Sometimes, the larvae mine the outer layer of skin of young green twigs also.

Life history: The eggs are usually laid singly on the underside of leaves near the midrib. They hatch out in about 3 to 6 days. On hatching, the young larvae enter the leaf tissue at once and start mining. The larval period may range from 1 to 2 weeks. The duration of the pupal stage, however, may last for 3 to 4 weeks, depending upon the season.

Control measures: The pest is extremely difficult to control, particularly after infestation has taken place, since the larvae are internal feeders. However, some relief may be obtained by an application of spray containing 1 lb. nicotine sulphate (40%), 4 lb. soap or 4 lb. of 50% wettable DDT in 80 gallons of water. This may kill the adult moths and the newly hatched caterpillars before they penetrate the leaf tissues. Heavy pruning of the infested shoots may precede spraying as it is advantageous in the destruction of the pest.

V. FRUIT-SUCKING MOTH

Marks of identification : The adults are large-sized moths having about a 3-inch wing expanse, and stout bodies measuring an inch in length. (Figs. 44 and 45). Their forewings are usually grey or reddish-brown with a greenish patch, the hind wings being orange or yellow with black spots or marginal dark bands and a strong elongated mouth-part, wonderfully adapted for punctuating the rind of fruits. The larva is a cylindrical stout-bodied semilooper having a dark-brown, velvety colour with cryptic markings; it is found usually on weeds belonging to the natural order of Menispermaceae and not on citrus.

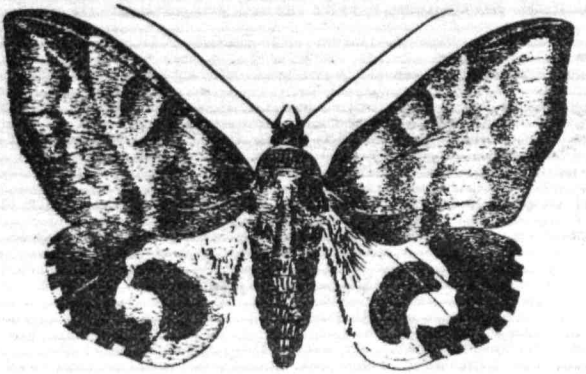

Fig. 44
A SPECIES OF FRUIT-SUCKING MOTH

Host plants: Moths generally puncture the rinds of all varieties of citrus. However, in Maharashtra State the damage is particularly serious on grape fruit and *mosambi.*

Nature of damage: The moths not only cause direct damage to citrus fruit but through their feeding injury open the way for bacteria which make the fruit rot quickly.

Life history: The female lays about 200 to 300 eggs on certain weeds. On hatching, the larvae feed on their foliage and enter the soil for pupation after maturity. The eggs require 3 to 4 days for hatching, the larval stage may extend to 13 to 17 days and the pupal period may last 12 to 18 days.

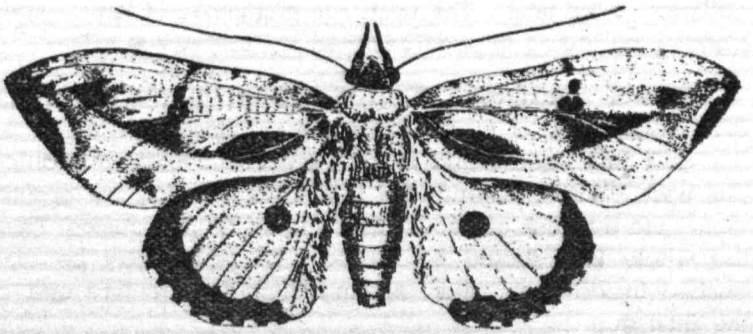

Fig. 45
A SPECIES OF FRUIT-SUCKING MOTH

Control measures: This is a very difficult pest, to control. Adults or moths have not been found to be controlled by insecticides hence bagging of fruits is at present the only reliable method of control. Attracting the moths to fermented poison baits and to torches and then killing them are other methods for detecting the moths and killing them. Removal of wild hosts of the caterpillar stage will also help to reduce damage.

VI. RED ANT

Marks of identification : The wingless ants or the workers, measuring about half an inch long, resemble household ants, except that they are slightly longer. The workers are orange-red. The male and female ants are greenish in colour.

Host plants : Although these ants do not feed on any plants, they spread all over the trees and build nests of leaves, thereby causing great nuisance. They are commonly found on such fruit trees as mango, citrus, *chikoo* and guava.

Nature of damage: They do not cause direct damage to plants but protect noxious insects like coccids, aphids, etc., for getting honey-dew from these harmful insects. Frequently, these harmful insects are found where red ants are present. Their enormous numbers and wanderings on trees, hinder harvesting of fruits and cause great nuisance.

Life history: Eggs are laid by the female and tended by the workers in the nest. The larvae and pupae are found in galleries in the nest. The nests are composed of leaves spun together by silken threads excreted by the larvae.

Control measures: 5% DDT sulphur dust (1 : 1) or 5% BHC sulphur (2 : 1) or either of these insecticides alone as 5% dust has been found to be very effective in controlling this pest. While dusting, the tree trunks and space around them upto a radius of about 5 feet should be first dusted. Then the whole tree should be dusted. The dust may be also pushed inside nests after piercing them by the fore end of the dust gun.

This treatment may be repeated after about 2 or 3 weeks.

VII. SCALE INSECT AND MEALY BUG

Marks of identification : The scale insects are small 1/10" in diameter or smaller and stationary, some of them are circular and others oblong and usually brownish in colour. When present in large numbers, the leaves and green stems have a spotted appearance. The female of the adult mealy bug is usually wingless with a flattened soft body covered with a white mealy powder; the male is, however, winged and has two blackish wings.

Host plants : Different species are found on a wide range host plants.

Nature of damage : They suck the sap from the tissues of leaves and shoots. As a result, the leaves and shoots get deformed and sometimes twisted into knots and loops in which the insects live.

Life history : Detailed life history of many species is not yet known. In some cases reproduction takes place parthenogenitically (i.e., without sexual union). The young ones which are crawlers move about for some time and settle down to feed, grow and reproduce. Once having settled down, the scale insects do not move, while the mealy bugs, though mobile, are sluggish.

Control measures : The pest can be controlled by two or three applications of a heavy spray of rosin compound at weekly intervals.

VIII. CITRUS MITE

Marks of identification : The adult is a small oval-bodied, red coloured or pale yellow, quick-moving creature and measures about 1/25" in length and has 8 legs. A freshly hatched larva has only three pairs of legs and in the subsequent stage, the fourth pair of legs is seen.

Host plants : Many species of mites attack cultivated crops such as mango, potato, betelvine and different varieties of citrus, guava, etc.

Nature of damage : The mites generally feed on the underside of leaves and also on tender fruits. As a result, a characteristic pale-yellow depression is seen on the attacked leaves and fruits. Due to infestation by some species, the

surface of the fruit initially becomes silvery and later turns brownish. The fruits fail to develop properly and fetch lower prices due to their ungainly appearance.

Life history : The details of their life history have not yet been investigated. The females of some of these may lay about 40 to 50 eggs which hatch out within a week or two. The nymphal stage may range from 2 to 3 weeks or less in which period the nymph passes through 3 to 4 moults before it becomes an adult mite, which is wingless.

Control measures : Application of sulphur dust or lime sulphur wash is one of the surest remedies to control this pest. For doing this, the damage must be detected as early as possible. At present this is the only satisfactory method of control. Though certain other insecticides have now been developed to control mites, they are not yet much in vogue in India. Symptoms of damage like silvery and brownish patches are generally noticed after the pest has disappeared. In the initial stage the damage is seen in dots and later the whole surface becomes similarly affected. Timely observation is, therefore, essential to ensure protection.

MANGO

The mango, the king of fruits in India, suffers from many serious maladies amongst which the jassid hopper, the stem-borer and the fruit fly are the most important. There are certain other minor pests like scale insects (Plate IV, Fig. 1) and twig borers, etc., which are not discussed here. However, the control measures recommended for scale insects may be referred to under citrus.

I. JASSID HOPPER

Marks of identification : The adult is a wedge-shaped insect measuring 1/8" in length, with a greyish body and having three dark brown spots on the head. It has a band in the middle and two black spots on the pronotum with a shield or plate having triangular black spots and a central longitudinal narrow dark streak dilated anteriorly and posteriorly. The nymph is, however, smaller than the adult. It is easy to recognise the pest by its diagonal active movement. (Plate IV, Fig. 3).

Host plants : The mango and *chikoo.*

Nature of damage : The nymphs and adults suck the young leaves and flower of trees. As a result, the flower withers and drops down without bearing fruit. They also secrete a sugary substance called honey-dew, which later permits development of sooty mould and thus imparts a black appearance of plants.

Life history : With the onset of the cold season, the adult female starts laying eggs singly in the tissue of flower, unopened flowers and young leaves from December to February. The eggs hatch into nymphs within 8 to 10 days. The nymphs turn into adults within 15 to 20 days. The breeding of the pest also takes place during the monsoon when egg-laying takes place in the midrib of tender leaves.

Control measures : The pest can be effectively controlled by two applications of 5% DDT sulphur dust mixed in the proportion of 1 : 1 or 1 : 2. The initial dusting is to be given after the first flush of flowering is complete, generally by the middle of December. The second dusting should follow about two weeks after the first application if the infestation continues. In some areas, only one dusting may check the pest for the rest of the season, while in others a second treatment may be found necessary.

II. STEM BORER

Marks of identification : The adult (Plate IV, Fig. 4) is well-built, conspicuously long, and brownish yellow in colour and measures about 2 inches long. It has orange-yellow spots on thorax and has hard upper wings. The larva is also conspicuous. When full grown, the grub is yellowish white, fleshy, and measures about 4"x¾" with a dark brown head having strong jaws.

Host plants : The mango, fig, rubber and jack.

Nature of damage : The grubs bore and tunnel through the stem. As a result, the affected branches start drying up and masses of refuse exude from the bored hole. In severe cases of attack, the branches may collapse and the tree may die.

Life history : The female beetle deposits eggs singly under the loose bark, or in the crevices of stems. The eggs hatch out in about 7 to 14 days. The grubs tunnel directly into the bark and take about 5 to 6 months to mature into full grown larvae. Later, they pupate in the stem and remain in the pupal stage for 4 to 6 months, after which they emerge as adult beetles.

Control measures : The best way to control the grubs is to inject borer solution containing 2 parts of carbon disulphide with one part of chloroform and creosote. An injection syringe proves handy for injecting the solution in the holes, after which it should be closed by mud. To economise, before injecting the solution, the live borers may be ascertained by scraping out the exhuded refuse and looking the following day for fresh refuse which will be there if the grub is present.

III. RED ANT

The same method of treatment is effective as that indicated in the case of citrus above.

IV. FRUIT FLY

This is one of the pests which attack guava. It is treated among the pests of guava which are discussed hereafter.

PESTS OF GUAVA

Amongst the many pests of guava, there are a few which are very important. These are the fruit fly, the shoot borer and the scale insects. Information on scale insects has already been given under pests of citrus.

I. FRUIT FLY

Marks of identification : The adult is a small insect measuring 1/5" in length as in the case of the housefly but characterised by conical shaped yellowish brown abdomen and transparent, outstretched wings with grey spots or bands on it. Brown and grey patches on wings distinguish these flies from others. (Plate IV, Fig. 6). The maggot which is found in fruits is a small dirty white-bodied legless larva measuring about ½" in length and tapering at one end. (Plate IV, Fig. 5).

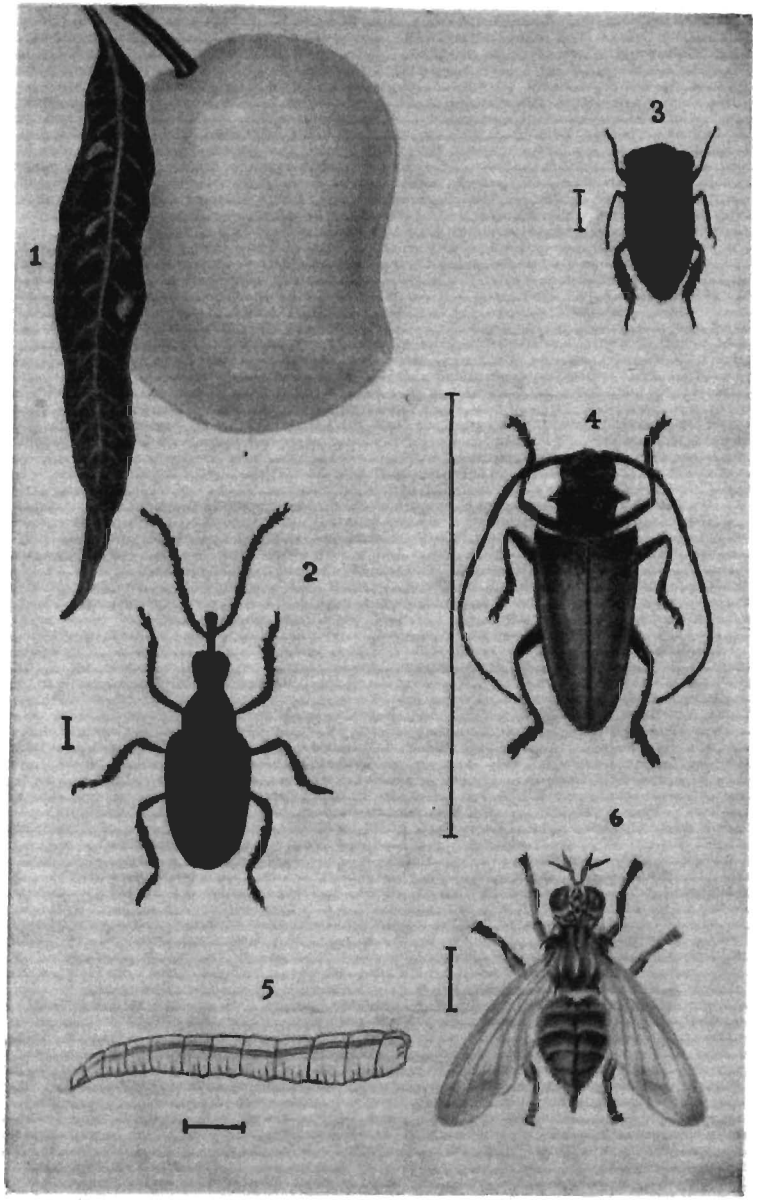

PLATE IV

PESTS OF MANGO

1 WHITE SCALE INSECTS ON LEAF; 2 MANGO LEAF TWISTER WEEVIL; 3 MANGO HOPPER; 4 MANGO STEM BORER; 5 MAGGOT OF FRUIT FLY: 6 FRUIT FLY ADULT.

Host plants : Besides guava, the fruit fly is reported to infest fruits of citrus, gourds, mango, melon, *tondli*, etc. A species also affects *'ber'* fruits severely.

Nature of damage : The flies lay eggs just under the rind of the developing fruit by puncturing it with the ovipositor. The maggots, on hatching, bore into the fruit and feed on its pulp. The infested fruits can be recognised by the presence of a rotten patch round the place of oviposition.

As the maggots grow, this patch extends and ultimately the fruit falls down. The incidence of this pest is more in late-maturing varieties of the guava and in the mango.

Life history : The female fruit fly deposits eggs singly or in batches on the developing fruits by first making a little depression by its ovipositor.

Eggs hatch in about 3 ot 5 days and the maggots are full-grown in about one or two weeks, by which time the fruit drops and the larvae leave the fruit and pupate in soil but sometimes in the fruit also if it is dry. The adult fly emerges within 8 ot 10 days. There are a number of generations in a year.

Control measures : Sanitation in the orchards is the most important measure against fruit flies. Daily removal and complete destruction of fallen and badly infested fruits should be done by burning them in very deep pits. Spot spraying with a spray bait containing 1 oz. tartar emetic, 24 ozs. jaggery and 20 lbs. of water may help to check the pest. The efficacy of organic insecticides has not yet been thoroughly investigated, but frequent spraying by 0.1% DDT water dispersible (1 lb. of 50% water dispersible DDT in 50 gallons of water) helps to check the pest by killing the adult flies. The adjoining hedges may be sprayed where the adult fly often takes shelter. However, these chemical measures are not fully and finally established for controlling fruit flies and hence the emphasis on sanitary measures.

II. SHOOT AND BARK BORDER

Marks of identification : The adult is a short, sturdily built moth, with a wing expanse of about one inch, and having grey marks on wings. The larva is a caterpillar measuring about 1½" in length and dirty-brown in colour with darkish head region.

Host plants : Guava, citrus, pomegranate, mango and casuarina.

Nature of damage : The freshly hatched larva bores into the stems and bark. It moves in a gallery made of powdered bark and silk, feeds on the bark and also enters the stem. As a result, the tree puts on a sickly appearance and ultimately it may die. Its presence can be readily determined by the appearance of frass-covered areas on the bark.

Life history : The female moth lays eggs on the bark. The larvae on hatching feed on the bark and enter the stem where they pass their larval and pupal stages.

Control measures : Injecting the borer solution containing 2 parts of carbon disulphide with one part each of chloroform and creosote is found to control the larvae of the borer **effectively.** Before injecting the solution, the galleries and webbings are to be scraped off and the live burrows ascertained.

PESTS OF POMEGRANATE

I. FRUIT BORDER OR ANAR CATERPILLAR

Marks of identification : The adult (Fig. 46) is a medium-sized greyish violet-coloured butterfly with a wing expanse of about 2". They female butterfly has a conspicuous orange coloured patch on the forewing. The full-grown larva is a short, stout, darkish-brown caterpillar with hairs and whitish patches on the body.

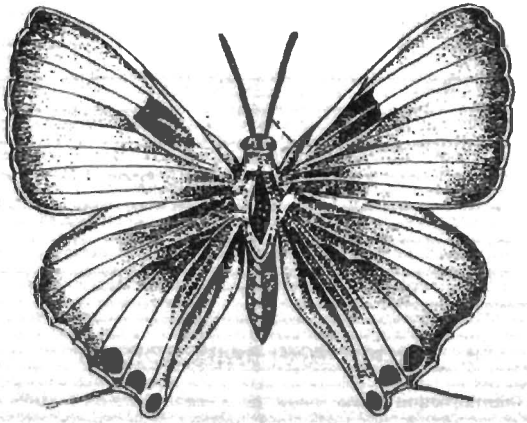

Fig. 46
POMEGRANATE BUTTERFLY

Host plants : Besides the pomegranate, it is known to attack fruits of the wood apple, guava, palm and tamarind.

Nature of damage : The larvae usually enter when the fruits are small and tunnel into the developing fruits and then cause rotting and bring about their premature fall.

Life history : The female butterfly lays shining white eggs (Fig. 47) singly on flowers or tender fruits. The larva hatch out within a week and enter the fruit by boring a hole and burrow into the fruit till they are about four weeks old, when they pupate. The pupation mostly takes place inside the fruit and lasts for about three weeks.

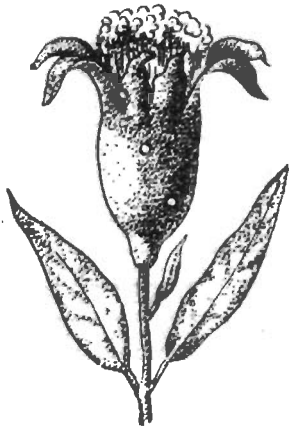

Fig. 47
EGGS ON POMEGRANATE FLOWER

Control measures : Two to three applications of a spray containing 1 lb. of 50% water dispersible DDT powder in 25 gallons of water, given at three weekly intervals during the flowering season has been found to control the pest to some extent. The treatment should start when the fruits are just beginning to form. Bagging of fruits with cloth or paper bags is also being practised with considerable success, though it is a rather laborious method.

PESTS OF COCOANUT

I. RHINOCEROS BEETLE

Marks of identification : The adult is an elongated stout black beetle measuring about 1½" in length and ¾" wide with a pointed horn like rhinoceros. The full grown larva is a stout fleshy grub measuring about 3-4" and in its natural position it is always curled up ventrally.

Nature of damage : The beetle bores into the tender parts biting fibrous portions. The injury can be easily seen by the characteristic series of holes in the fronds and the fibrous mass oozing out of them. Where the damage is serious the tree withers and may ultimately die.

Life history : The beetle passes its early stages in the manure pits or sometimes in decomposing organic matter at the top of a dead palm. The female lays oval seed-like eggs singly in the decomposing manure. They hatch within about 10-12 days. The larvae feed on manure and take 4 to 5 months for developing into full grown grubs which later construct pupal chambers made of fibrous matter and soil and enter the pupal stage. Within 3 to 4 weeks adult beetles emerge.

Control measures : (1) Its breeding places like manure dumps and compost heaps may be treated with 0.1% BHC (w/d) every two months.

(2) The opening up of small trap pits in different parts of a coconut plantation filled with decaying cattle manure and vegetable matter and treating the stuff with 0.1% BHC (w/d).

(3) Extracting and killing adult beetles by the use of a beetle rod. This is particularly recommended for young plantations upto about ten years of age when fresh infestation is noted.

(4) Filling the beetle holes and the inner leaf axils with sand and 5% BHC dust in equal proportions. This treatment may be repeated every three months.

II. RED PALM WEEVIL

Marks of identification : The adult is a reddish brown, smooth cylindrical weevil, measuring about 1" in length and about ½" in width with a long prominent snout in front. The full-grown larva is a fleshy grub of a pale yellowish white colour.

Nature of damage : The grubs of the weevil pass their life on the palm tree itself and cause damage by tunnelling through their soft tissues.

Life history : The eggs are laid on scars or holes caused by mechanical injury or by rhinoceros beetles. The eggs hatch into whitish grubs which pass their life by feeding on the soft tissues of the palm. They pupate by forming cocoons of fibrous matter and emerge later as weevils.

Control measures : The injections of Pyrethrines Pipernyl butoxide combinations (Pyrocone E) at 1% strength into the affected parts of the coconut palm are recommended.

III. BLACK HEADED CATERPILLAR

Marks of identification : The adult is a medium-sized moth with uniform pale whitish upper wings. The full grown larva is a slender elongated pale grey caterpillar with a blackish head.

Nature of damage : The caterpillar feeds on the tissue of the leaf, generally remaining in between the fold of the leaf and galleries made of silken threads and excreta. As a result, dried up patches are seen on fronds and trees start withering which may later result in reduced breeding.

Life history : The female moth lays scale-like eggs in clusters on the underside of the leaf, especially near the old larval galleries. On hatching the caterpillar starts feeding on the tissues of the leaf till it changes into a brownish pupa inside the gallery from which the moth emerges.

Control measures : (1) Breeding and releasing of parasites.

(2) The affected whorls of leaves in the case of severe and concentrated infestation of the pest should be sprayed with BHC or DDT 0.2% (w/d).

IV. TERMITES

These are sometimes serious pests of young coconut palms.

Control measures: The use of DDT wettable at 0.2% strength in coconut nurseries and young seedling is recommended.

V. RATS

Control measures : Keeping baits treated with zinc phosphide (1 oz. in 16 oz. of base) or warfarin (1 part in 19 parts base) in the crevices of the coconut palms has been found to be effective. Since the chemicals are highly poisonous it will be necessary to use them with caution.

PESTS OF GRAPE

I. FLEA BEETLE OF UDADYA BEETLE

Marks of identification : The adult is a small, coppery-brown beetle, measuring about 1/3" in length, with three prominent circular patches on each of the upper wings which are hard. The larva is a small, dirty-white grub, measuring about 1/3" in length, usually found in the soil.

Host plants : Although it is singularly monophagous, feeding on grapes only, it is found sometimes to scrape the lower surface of the leaves of *pangara*.

Nature of damage : Early in April or in October when the grape-vines are pruned and the buds begin to sprout, the adult beetles bore into the sprouting buds and eat them completely without allowing them to develop. Their feeding on mature leaves creates elongated holes on the leaf-blade, giving it a shot-hole appearance. The grub is a root-feeder but does not do serious damage to the root system.

Life history : The female beetle deposits eggs under the bark of the vine. The egg stage lasts for 3 to 7 days. On hatching, the grubs fall down into the root zone and start feeding on the roots. The larval stage may last from 5 to 6 weeks, after which the grubs pupate in an earthen cell, from which the adult beetle emerges within a week.

Control measures : Two to three applications of a spray containing 4 lb. of 50% wettable DDT powder in 100 gallons of water, given at fortnightly intervals after pruning in October or April, have been found to be very effective in controlling this pest.

II. THRIPS

Marks of identification : These are minute pale, white-bodied insects, measuring about 1/25" in length. The wings of the adult have a characteristic fringe. Hence the insect is often called a fringed-wing insect.

Host plants : Thrips have a large number of host plants, as in the case of aphids.

Nature of damage : Generally, they feed on the under surface of leaves by scraping the epidermis which initially develops a whitish patch and later may turn brownish. The pest is more likely to become abundant in the post-monsoon period from September to November.

Life history and control measures : Their life history is similar to that of cotton thrips, to which reference may be made. As regards control measures, the treatment given for the Udadya beetle should also control these pests and if, however, DDT is proposed to be used for thrips control alone, the dilution may be reduced to 2 lbs. of 50% water dispersible powder in 100 gallons of water.

By G. A. PATEL and G. M. TALGERI.

CHAPTER XVI

STORED GRAIN PESTS AND THEIR CONTROL

I. RICE WEEVIL

Marks of identification : The adult is a small beetle about one-sixth to one-eighth of an inch in length and reddish brown, dark brown or almost black in colour, with the head having the shape of a long slender snout (Fig. 48 c). The wings have four light-reddish or yellowish spots and the insect is able to fly. The grubs are small, white and legless, with a yellow-brown head. They are always found inside the kernels and never outside.

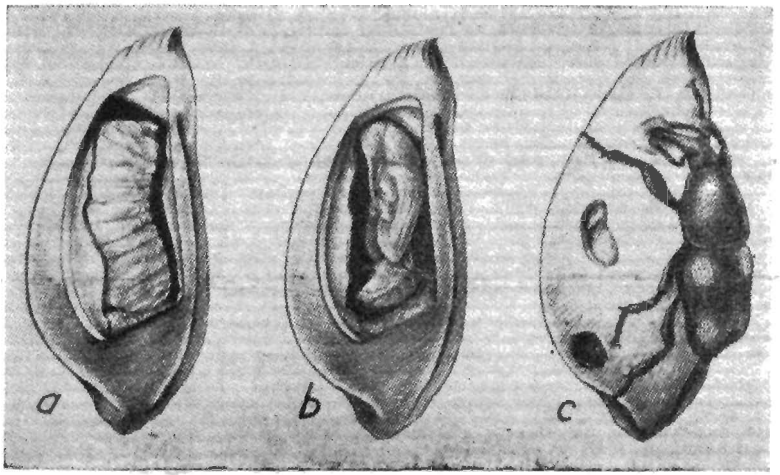

Fig. 48
LIFE STAGES OF THE RICE OR BLACK WEEVIL IN WHEAT; a, WELL-GROWN LARVA; b, PUPA; c, ADULT FEEDING UPON KERNEL

Nature of damage : The pest feeds on while grains of wheat, rice, maize, jowar, barley, bajri, etc. Both adults and larvae feed vocaciously on the grain so much so that the grain becomes unfit not only for consumption but also for seed purposes. In case of heavy infestation, the grain becomes a mass of broken vegetable matter. The adults eat a small amount of grain, making shallow holes with rugged edges into it but the amount of damage thus caused

is negligible as compared to the complete hollowing of grain which the larvae effect (Fig. 48 a).

Life history : The adult female bores a small, round hole in the soft part of a grain by means of the mouth-parts on the tip of her snout and there she lays a single egg and plugs the hole with mucilaginous material. The egg is oval in shape and white in colour, and is extremely minute, about 0.7 x 0.3 mm. in size. A female can lay about 250 to 400 eggs during her life-time. The egg stage lasts about four days in summer but is extended to six to nine days in winter. The young tiny grub bores innto the grain kernal and lives within the grain, feeding on its starchy content and hollows it out, leaving only the outer shell intact. The grub stage lasts for from 19 to 34 days. The full-grown grub makes a pupal cell inside the grain and pupates after passing one or two days as a pre-pupa. The pupal stage lasts for three to six days generally but sometimes as long as 20 days. The adults live on an average for two to five months, depending upon the season : the life-cycle of the pest is shorter in summer than in winter.

II. GRANARY WEEVIL

This insect is similar to the rice weevil in general habits and biology, but it differs from it chiefly in being longer, uniformly brown with polished elytra and longer punctures on the thorax. Unlike the rice weevil, this insect is unable to fly, as its wings are fused.

III. LESSER BRAIN BORER

Marks of identification : The adult can be distinguished from other store pests by its slender cylindrical form and small size one-eighth to 1/32 of an inch long). It is polished, dark-brown or black in colour, with a somewhat roughened surface (Fig. 49 c). Its head is located just below the front end of the thorax and turned somewhat downwards, so that it is scarcely visible from above. The larvae are in the grain (Fig. 49 a) or crawl about actively. The full-grown larva is dirty-white and has a light brown head and its body is covered with tiny hairs.

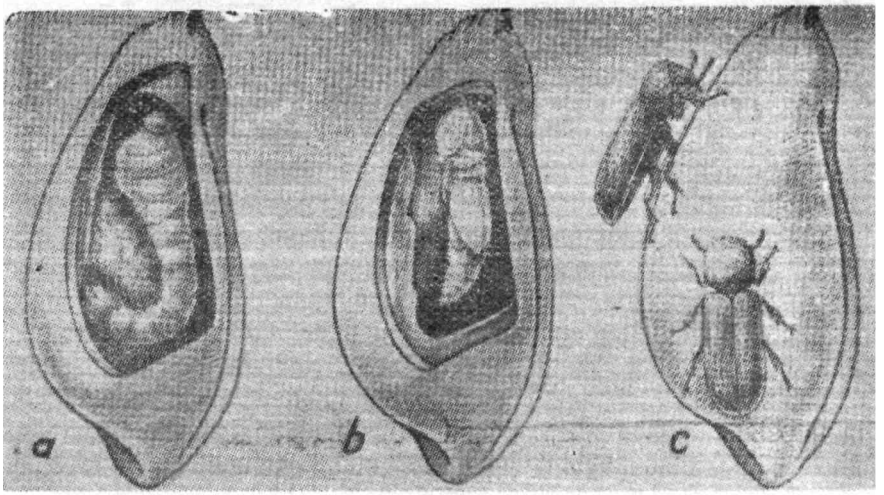

Fig. 49
THE LESSER GRAIN BORER IN AND ON WHEAT KERNELS: a, THE WELL-GROWN LARVA; b, THE PUPA; c, TWO ADULT BEETLES

Nature of damage : It feeds on wheat, rice, jowar, bajri, maize, pulses, paddy, etc. The damage caused by the lesser grain borer is easily distinguished from that caused by weevils by the voracious eating of the larva and the beetle, both of which make large irregular holes in it, eventually resulting in the complete break-up of the grain. The adult appears to chew a great deal more gain than it needs for food.

Life history : The female lays eggs, singly or in clusters on the grain or sometimes on walls, on bags or in cracks in godowns. A female can lay from 300 to 500 eggs, which are pearl-shaped, glistening-white when fresh and become pinkish and opaque when mature. The egg-stage lasts five to six days in summer and longer in winter. The larva passes its life inside the grain or it is seen freshly in grain, and it undergoes four to five moults but rarely three. Its larval period on an average lasts 44 days but it becomes shorter in summer and longer in winter. Pupation takes place either inside the grain (Fig. 49 b) or outside it and continues for seven to eight days. The adult is hardy, can live for eight to ten months and may live without food even for a couple of months.

IV. KHAPRA BEETLE

Marks of identification : The adult are two to three mm. long, are brown in colour and stout in build, have grey and light brown markings, and are oval in shape. The male is smaller and darker than the female. The larva is brownish-white in colour, with the body covered with bundles of long reddish-brown hair and forming a sort of a thick tail at the posterior end.

Nature of damage : It is particularly a bad pest of wheat but also infests jowar, bajri, rice, pulses and other grains. The adult is harmless, the larva alone being destructive. Generally, infestation occurs in the superficial layers of grain. The larva destroys any part of the grain but very frequently the embryo is damaged, resulting in decreased germination of grain, long before any serious quantitative damage is detected.

Life history : The eggs are laid loose among the grains. A single female lays in her life-time about 125 eggs. The egg-stage lasts 6 to 16 days, depending upon humidity and temperature. The larval period varies considerably. Generally, there are four moults in a period of 50 days, but the number of moults are doubled and the duration prolonged for a period of 200 days or even up to four years under adverse conditions of temperature and humidity. During winter and in the absence of food, the larva hibernates in cracks and crevices of godowns or in seams and meshes of bags. The pupal stage lasts from 6 to 17 days and the adult lives for 10 to 30 days.

V. RUST-RED FLOUR BEETLE

Marks of identification : The adult (Fig. 50) is a small, flattened, reddish-brown, smooth insect, about one-eighth of an inch long. The larva is small, worm-like, slender, cylindrical and wiry in appearance, and when grown, it measures three-sixteenths of an inch in length and is pale-yellow in colour. Generally, it does not damage sound grains, but when it does it is observed to infest the germ part of sound grains and feeding from small lesions in the grain. It is a serious pest of broken grain, specialy rice, and milled products like **atta, maida, suji,** etc. In cases of heavy infestation, flour or **maida** turns greyish-yellow and subsequently becomes mouldy and emits a pungent smell, acquiring an unpalatable and objectionable taste. The pest is particularly abundant in flour mills.

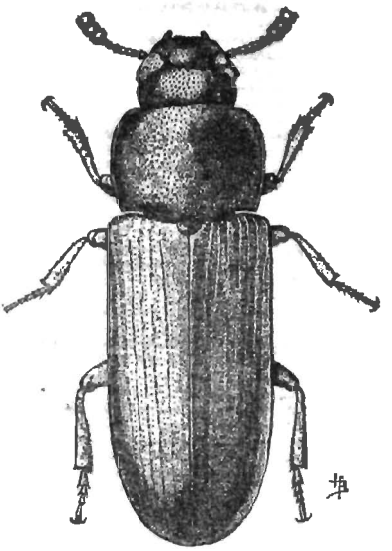

Fig. 50
THE RED FLOUR BEETLE

Life history : The eggs are laid freely in flour, etc., and as they are rather moist, they stick when freshly laid, after which they soon become covered with small particles of dust and flour. They are small, slender, cylindrical in shape, rounded at both ends and of whitish colour. A single female lays about 450 eggs. The egg-stage lasts for five to 12 days. The larva, which is free and not in the grain, completes its development in 27 to 90 days, according to the availability of food and the range of prevailing temperatures. Pupation generally takes place on the surface of the foodstuff and lasts six to eight days. The adults are active and hardy, can stand starvation even upto two months and normally live for four to six months.

VI. SAW-TOOTHED GRAIN BEETLE

Marks of identification : It is a small, narrow, flat, brown beetle, about two and a half to three millimetres long. Its common name is derived from the peculiar structure of the thorax of the adult, which bears saw-tooth-like projections on each side. The larva is free and active, and is slender and whitish in appearance.

Host substances and nature of damage : The larva feeds mostly on flour, 'maida' or the waste flour produced by the infestation of other primary pests. The adult also attacks damaged grain. It is a bad pest of oats and other grains, when they become moist. Excessive infestation of this beetle on food products, particularly cereals, makes them unpalatable and unsaleable.

Life history : The eggs are dropped loose among foodstuffs or tucked away in crevices or among grains. From 45 to 285 small, slender, white eggs are laid by a single female. The egg-stage lasts from three to five days in summer and about 15 days in winter. The larval period lasts from 12 days to as long as 10 weeks. The full-grown larva makes cells by sticking together particles of foodstuffs with a substance which it secretes. The pre-pupal and pupal stages are passed inside these cells. The pupal stage lasts from one to four weeks. The adults are hardy insects with well developed wings, but they seldom fly. Ordinarily, they can live for six to ten months, but may sometimes live for more than three years.

VII. LONG-HEADED FLOUR BEETLE

Marks of identification : The adult is closely allied to the rust-red flour beetle. It is slender, flattened, one-eighth of an inch long and pale brown in colour. The larva is yellowish-white, with a dark head and legs.

Nature of damage : This beetle prefers flour or grain debris but occurs fairly frequently as a secondary pest of stored grains which are already broken by other primary pests. Thus, the damage done by it is similar to that caused by the rust-red flour beetle.

Life history : Its life history, too, is similar to that of the rust-red flour beetle in its main features. The eggs are cylindrical in shape, opaque and smooth. Its life-cycle is completed in a period of 25 to 32 days. A female lays about 150 eggs and the egg-stage lasts four to six days, while the larval period varies from 24 ot 48 days, the pupal period being five to nine days.

VIII. FLAT GRAIN BEETLE

Marks of identification : The flat grain beetle is a small flattened, slightly oblong and reddish-brown insect about one-sixth of an inch in length, with elongated antennae about two-thirds as long as its body. It is one of the smallest beetles found in stored grains. The larva is cigar-shaped, yellowish-white, with a reddish-brown head and spine-like appendages on the anal segments. The full-grown larva is creamy-white in colour.

Nature of damage : It is by nature a feeder on powdered grain. The adult appears apparently unable to infest sound, uninjured grains. Therefore, it generally appears after an initial attack by such primary pests as the rice weevil. The larva is particularly fond of wheat embryo and, on account of its scavenging habits, it infests grain and meal that is out of condition.

Life history : The eggs are deposited in crevices or in grains or dropped loosely on flour, etc. The larva makes cocoons of a gelatinous substance, to which the food particles adhere. It takes usually about six weeks for the beetle to develop from the egg stage to the adult stage.

IX. ANGOUMOIS GRAIN MOTH

Marks of identification : The moth is a small insect, dry-grass, buff or yellowish-brown in colour, with a wing expanse of half an inch. The wings are narrow and fringed. The larva is whitish in colour with yellowish heads. The tiny caterpillar penetrates the grain and remains there for the rest of its life. It is never found free and separated from the grain.

Nature of damage : The initial infestation, though slight, usually takes place in the field when the grain is in the milk stage. When the grain is threshed and stored, infestation is restricted to the surface layers only. This pest causes injury to grain only during its larval stage, as it feeds within the endosperm of the grain, leaving the rest of the grain untouched. The presence of larva inside the grain is unsuspected until the moths appear in the stores and round holes are seen in the grains on account of the emergence of moths (Fig. 51). The infested grains are hollowed out by the larva and filled up by their excreta and webbing. It is chiefly a

pest of paddy and jowar, but is also found on wheat and barley.

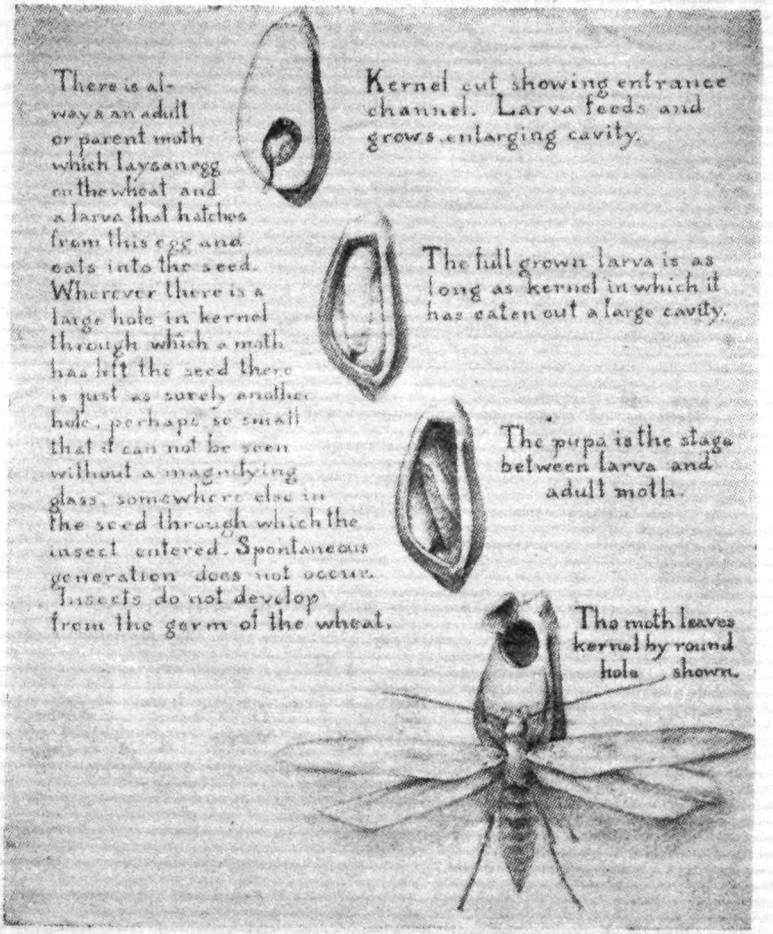

Fig. 51
LIFE CYCLE OF THE ANGOUMOIS GRAIN MOTH ON WHEAT

Life history : The female moth is capable of laying 120 to 400 eggs, which are deposited in depressions, cracks, crevices and holes in grains or even on immature grains on ears in the field. The eggs are oval and white when fresh, but soon become bright red. The egg-stage lasts for about

Life history : The eggs are laid on bags or walls, etc. A single female can lay from 90 to 200 eggs, which hatch in about five days' time. The larva takes shelter inside the webbings made of grain, excreta, frass, etc., and then feeds. The larval period lasts about 15 to 40 days and pupation takes place inside the silken galleries or 'jalas'. The pupal period is completed in about 12 to 15 days. The adult is short-lived and lives for four to six days only. Like other moths, it does not cause any damage but perpetuates the species and increases the degree of infestation.

XXII. INDIAN MEAL MOTH

Marks of identification : The adult moth has a wing expanse of from one-half inch to three-quarters of an inch, forewings lustrous brown with yellowish or whitish bands across the basal half (Fig. 54). The larva is grey white in colour and about half an inch long when mature. Its body is covered with hairs and the skin is granular (Fig. 55).

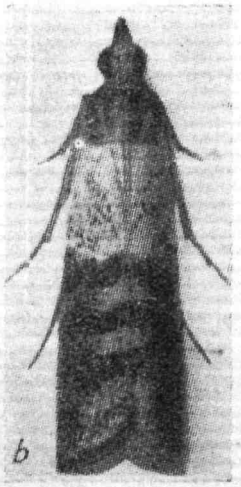

Fig. 54
THE INDIAN MEAL MOTH WITH WINGS FOLDED AS ORDINARILY SEEN WHEN IT IS RESTING ON SOME SURFACE IN THE WAREHOUSE

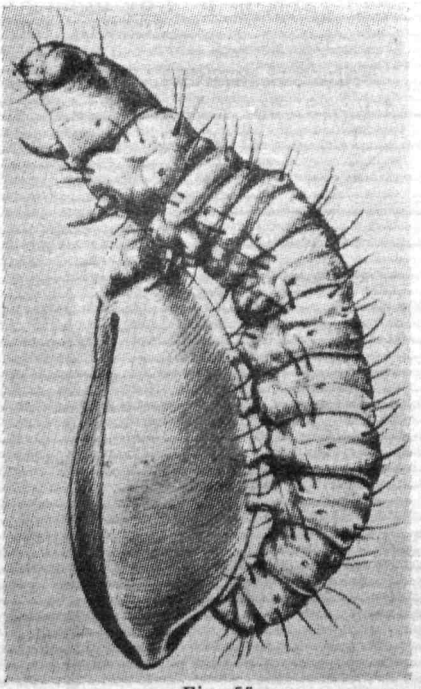

Fig. 55
WELL-GROWN LARVA OF THE INDIAN MEAL MOTH, CRAWLING ON KERNEL OF WHEAT, MUCH ENLARGED

Nature of damage : It is a major pest of imported wheat on whose germ portion the larva feeds. During that process, tubular webbing is formed by it either on bags or on the bulk of the food material. In serious cases, the bags or flooring is completely covered with silken sheets.

Life history : The eggs are laid singly or in groups on the food material. On an average 200 eggs are laid by a single female and they hatch in a period of five to seven days. The larva lives free but comes out on the surface of bags and spins cocoons for pupation after about 30 to 40 days. Pupation occurs inside the cocoons which are attached to the bags or are sometimes naked. The pupal period lasts 12 to 15 days, while the adult can live for from two to 15 days.

XIII. PULSE BEETLE

Marks of identification : The adult, which can fly readily, is usually less than a quarter of an inch in length and, when viewed from above, presents a heart-shaped appearance, with two ivory-coloured spots in the middle of the dorsal side of its body. Its body, however, tapers a little towards the head. Its colour is chocolate or dark brown and it has a conspicuously swollen abdomen. The grub is white, cylindrical, fleshy and wrinkled, found always inside the grain and has brown mouth-parts.

Nature of damage : 'Mung', 'gram', 'tur', 'lang', 'bean', 'masur' (lentil) and 'udid' are generally infested when the grain is whole; split pulses (Dal), excepting split gram, do not suffer any such damage. The eggs are sometimes laid in the field on green pods which carry the infestation to stored pulses. The young grub burrows into the pod or grain when small and continues to develop inside the grain and later emerges as an adult after completing the pupal period. Thus, the holes seen on pulses are exit holes from where the adults have escaped. Such grains cannot be used for seed purposes.

Life history : The eggs are deposited mostly singly but sometimes in groups on the surface of seeds and pods. One single female can lay from 60 to 95 eggs in her life-time. The

egg-stage lasts four to five days, while the larval period, which is passed inside the grain, continues for two or three weeks. Pupation also occurs inside the grain and lasts for about four to eight days. The adult can fly readily and thus spread infestation from store to field at or before the harvest. The adults can live for 10 days or even longer.

XIV. MITES

Marks of identification : Mites are pale, wingless, greyish white, smooth, soft-bodied, microscopic creatures, which are not insects. The adults have eight legs instead of six, as in insects, and the body is divided distinctly into two parts unlike the three parts of the head, thorax and abdomen found in insects. They belong to the same group as ticks on dogs and cattle, but are extremely small in size.

Nature of damage : Mites flourish under humid conditions of the atmosphere and hence their presence in grains or grain-products usually indicates a high (i.e. 12% or more) percentage of moisture. They are known to damage the germ part of wheat. Apart from this, they impart a typical unpleasant odour to the infested material and further losses result due to heating, increase of moisture and development of moulds.

Life history : The eggs are laid on the food material where the young mites grow rapidly. The life-cycle from the egg to the mature mite may be completed in a little over two weeks. But when conditions are unfavourable, they pass into an inactive, non-feeding and very resistant stage, which enables them to tide over such periods. They can remain in this condition for a number of months without food and, when favourable conditions return, they moult and become active again.

CONTROL OF STORED GRAIN PESTS

Though the species of insects found in stored grains are many, their living habits are similar in certain respects. Thus, most of them lay eggs on the grain, breed inside the grain, in the case of primary feeders, or on broken grain or powder, in the case of secondary pests. The pupal stages are also

passed in the midst of the grain. The mouth-parts of the stages by which damage is caused are all of the biting type. Thus, as the general habits are similar, the control measures are likewise alike.

These measures can be divided into preventive and curative. More than in any other field of insect control here the preventive measures are of greater importance and value. For longer and safer storage, it is very essential that the grains to be stored should be sufficiently dry. It is believed that most species of stored grain insects will not multiply excessively in grain with less than 8% moisture. Thus, the household practice of farmers and others to dry the grain has a scientific basis. The sunning of grain before storing also helps in the destruction of many other insects coming along with harvest. Another preventive step is to stop contamination of the new grains from the old infested grain or from the remnants of grains and insects in the godown or the bins or gunnies used previously for storage. It is, therefore, necessary to look to these points when new grains are brought in for storage.

In large Government godowns, when grain is stored in gunnies and in stacks, it is often the practice to dust the outside of the stacked gunnies with 4% BHC in order to prevent the insects of one bag infesting another bag and those in the godown from going inside the bags. This practice, however, is not always practicable for all. Further, it should be noted that the insecticide is not to be mixed with the grains, as most insecticides are poisonous to man if taken in sufficnent quantities.

Grains which are already infested should be first sieved and cleaned so as to remove different stages of the pests. The grains should be sunned and then fumigated with any of the following fumigants. However, when large quantities are to be handled, it is not possible to do so, and hence fumigation may be adopted directly. For small-scale work, any closed containers like metal tins and 'Kathis' and 'Kanagies', etc., are useful, provided they are properly closed after introducing the fumigant. In the case of many fumigants, it is necessary

to keep the container tightly closed for a number of hours and the necessary exact exposure stated is given in the table below. After fumigation, if there are no immediate chances of re-infestation, the containers may be kept slightly open for a day or so, so as to aerate them and thus allow the escape of the absorbed gases. Such fumigated grains should not be eaten immediately and it is advisable to use them only after aerating them for a day or two. For grains to be kept for long periods, it is best to fumigate them thrice during a year —once after winter and again shortly before the monsoon and the third time about the end of the monsoon.

Fumigants	Available as	Rate at which to be used	Period of exposure	Precautions
Carbon disulphide	Liquid in bottles	1 lb. per 100 cubic feet of space	24 hours	1. Keep away lighted matches, cigarettes, etc., as it is inflammable. 2. Do not smell it excessively. 3. Safe for seeds.
Ethylene dichloride-carbon tetrachloride (ED/CT)	Liquid	2½ lbs. for 100 cubic feet of space	24 hours	1. No chances of catching fire. 2. It is relatively safe but do not inhale excessive amounts. 3. Safe for seeds.
Methyl bromide	Gas under pressure in cylinders	1 lb. for 1,000 cubic feet of space	48 hours	1. Not to be used by laymen. 2. Use a gasmask while working. 3. Dangerous to human beings and pets. 4. Not quite safe for seeds.

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CHAPTER XVII

DESERT LOCUST AND ITS CONTROL

The desert locust is a pest of world-wide importance as it is known to migrate in swarms from one country to another, leaving behind utter destruction and famine. A writer has picturesquely described the havoc wrought by locusts thus : "Before them is a smiling heaven, behind them a barren, battered hell". It is a denizen of the dry sandy desert and is an international pest, being found in India, Pakistan, Afghanistan, Arabia, Persia, Iraq and Africa. In India, periodical visitations of this locust have been recorded since long.

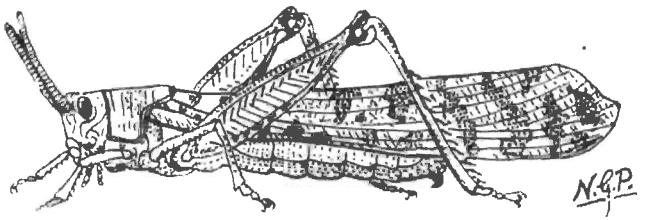


Fig. 56
THE DESERT LOCUST

Description : Young wingless locusts emerging out of eggs are known as hoppers. These hoppers in the swarming phase are generally blackish-brown, with a pale median line on the head and body. When they are in the solitary phase, however, they are generally greenish in colour with traces of black markings.

The freshly-developed winged locusts of the swarming phase are pinkish in colour with elongated leathery wings. They turn brownish as they grow older and later turn bright yellow when they are sexually mature (Fig. 56). They have a strong wild-looking head, with a strong collar, inside which moves the neck. Their legs are powerful and peculiarly formed with the lower part of the hind leg coloured yellow. The adults of the solitary phase remain grey throughout their life. If, however, favourable conditions prevail for their crowding, they become gregarious and turn pink, brown and then yellow.

Life history : As in the other species of locusts, the desert locust also has two phases, namely (i) solitary, and (ii) gregarious or swarming. In the former phase, the locusts are seen as individuals which develop in isolation, while in the latter phase, they are seen in crowded groups of individuals which result from their abundant multiplication in the breeding areas. This crowding of individuals stimulates insect activity, increasing their metabolic rate, which causes them to eat more, grow faster and larger with longer wings and ultimately induces them to move in swarms.

The locust passes through three stages during its life, namely, the egg, the hopper and the adult.

The hopper feeds on many wild and cultivated plants. When present in large numbers, the hoppers are known to defoliate field after field as they march along. The winged swarms migrate over long distances and, when they settle on green vegetation, they are known to destroy several square miles of standing crops in an exceedingly short time.

The female locust, soon after pairing, lays a mass of 50 to 100 eggs in a hole drilled by herself in moist sandy soil. After laying the eggs, the hole gets closed with a frothy liquid secreted by the locust, which ultimately hardens into a sort of water-proof plug. Since locusts in the gregarious phase fly or rest together in swarms, egg-masses are generally found laid very close to one another. The eggs generally hatch in two to four weeks, depending upon soil moisture and temperature.

As the young hoppers of the gregarious phase grow, they shed their skin once every three to five days, so that it may be possible for them to attain a progressively larger size. A locust hopper generally undergoes five successive moults before it acquires wings and becomes an adult. The hopper stage lasts for about four to six weeks, depending upon the season and food. The most interesting feature in the behaviour of hoppers is their mass movement in bands, sometimes several square miles in extent, composed of many millions of individuals marching relentlessly in close formations across the countryside and feeding voraciously on all vegetation in their path. These hopper bands generally rest between sunset and sunrise in bushes, crops or trees.

The adults are bright pink or brown in colour in the gregarious phase and grey in the solitary phase. When pink-coloured, they are very active and are likely to cause a great deal of damage to crops. The movement of the locust swarms apparently depends on conditions of weather then prevailing. These pink locusts, when sexually mature, turn bright-yellow in colour. The yellow swarms, though not so destructive to crops, are potentially more dangerous, as they lay eggs in a very short time. The adult swarms can fly at speeds of eight to ten miles an hour. At dusk, they settle down on bushes, trees or crops. If there is a cold spell, they prefer to settle down on trunks of trees rather than on crops.

The pest breeds during the spring season in the coastal and other areas of West Asian countries like Persia where the winter rains bring about the required degree of soil moisture and vegetation. The adults emerging from this breeding stage migrate eastward to Pakistan and India about the beginning of the monsoon in our country. By the time monsoon showers create sufficient moisture and vegetation, these migrating swarms are sexually mature and they lay eggs in the desert areas of Rajasthan, Maharashtra, Sind, etc., where the hopper stage develops, which causes severe destruction to Kharif crops. These hoppers develop into winged adults capable of flying long distances by the end of the monsoon. Later, with the beginning of the easterly winds of

the winter season, the pest migrates westward, causing damage on its way back to mature Kharif crops and early Rabi crops in India and then to the West Asian countries where they again breed in spring after remaining inactive in the adult stage during winter-time.

In years of severe infestation, winter or spring breeding also takes place in the Punjab (India) in the north, but as stated earlier, the Kharif season breeding is of importance to Rajasthan and Maharashtra State ; the winter or spring breeding, however, is not known in this latter area due to lack of rain and moisture during that season.

Methods of locust destruction : The chief aim of locust control operations is to destroy the locust in all its stages, namely, the egg, the hopper and the adult.

Destruction of eggs : Locating egg-laid areas is of the utmost importance, as it leads to timely action on freshly emerging hoppers, which operation is not even a tenth as difficult as effecting control of grown-up bands of hoppers and winged swarms. After these areas are located, the first step is to trench them round so as to entrap the young hoppers as they move out after hatching. In case it is not possible to trench the egg-laid areas, actual destruction of eggs on an organised scale should be carried out, wherever possible. This can be accomplished thoroughly by ploughing, harrowing and hand-digging. Unfortunately, however, as this method is laborious and rather costly, it does not have a wide appeal. Besides, the desert locust frequently lays eggs in desert areas which are not easily accessible and hence such cultural operation are rendered difficult, if not altogether impossible.

Hopper control : Locusts at the hopper stage can be destroyed by both mechanical and chemical methods. The mechanical methods include entrapping, marching hopper-bands in trenches of 2′ × 2′ having smooth upper sides and burying the hoppers in them, or killing them by providing barriers of metal sheets over which the hoppers cannot jump and thus directing them to move into pits in which they can be easily buried. The chemical methods are by far the

best. These include use of poison baits and dusting of insecticides. Poison baits are prepared by mixing materials like wheat bran, rice bran, pulse husk or even saw-dust with benzene hexachloride (BHC) or paris green or sodium fluosilicate to the extent of 5%. Suitable attractants in the form of molasses are also mixed with bran. The bait is broadcast on the path of hoppers which get killed when they feed on it. The use of baits has serious limitations, because of the difficulty of procuring materials like bran in areas where locust operations are to be carried out. Dusting of 5% to 10% BHC against hoppers at the rate of 25 to 30 lbs. per acre has been found to bring about a complete control of the pest in such a short time as 12 hours. The earlier stages of locust hoppers are quite susceptible to 5% BHC, while 10% BHC is required to kill the later stages of the locust.

Control of adult locusts or winged locust swarms : Destruction of freshly-moulted adult locusts can well be effected by dusting 5% BHC. However, when the adults are a little mature, their susceptibility to BHC decreases. Nevertheless, in such cases some measure of success can be achieved in reducing swarm intensity by using 10% BHC.

When the swarms are resting on bare ground at night or in early morning when it is cool, they are lazy and can therefore be beaten or swept up and destroyed. If they are resting on bushes or hedges they can be easily burnt with the help of flame throwers (Plate VI).

When flying locusts are about to descend in large swarms on cultivated areas, the best way to tackle them is to prevent them from alighting by all possible methods, such as waving a white cloth, or creating a cloud of smoke by burning refuse, etc.

By G. A. PATEL and G. M. TALGERI

CHAPTERS XVIII

TERMITES AND THEIR CONTROL

In the temperate zone, the termites have primarily attracted attention due to the damage they cause to building timber. In the tropics, this phase of the problem is by no means less acute, but in addition to this, the destruction they cause to cultivated crops is also a problem to be tackled.

In Maharashtra State, particularly in the Deccan, the termites build tall nests or termitoria overground and they are then called mound-building white ants. In these latter regions, the termites are more abundant in forest and other uncultivated areas and hence reports of their infestation from farmers are less frequent.

In the northern districts of Maharashtra State, many times the termites have been incriminated for the destruction of cotton, chillies, wheat, egg-plant, groundnut, sugarcane and stems of otherwise vigorous trees in mango plantations. Citrus, 'guava', 'chiku', and pomegranate are the other fruit trees which are injured by this pest.

The damage to cotton, chillies and egg-plant is of doubtful significance. These crops are known to be susceptible to root-rot fungus, which appears to be the primary cause of death and this apparently opens the way for termite injury. The characteristic symptom of root-rot, such as the decaying bark of the diseased roots, is quite obviously indicated in plants reported as being damaged by termites. In many instances, root-rot fungus has also been isolated from such plants. Reports of damage to wheat crops are often confused with the symptoms caused by the root-rot of wheat which acts as a precursor of termite infestation. In the case of sugar-cane, it is likely that the red-hot fungus may be of some significance in encouraging or even inviting termite injury.

Termite and fungus injuries are often regarded as interconnected. Some believe that termites are essentially saprophytes and do not infest growing tissues and injure only those plants which are dead or dying as a result of fungus disease or similar other causes. Others hold that the opposite may be the case. It is, however, interesting to note that in Gujarat only those crops which have some root disease are generally attributed to have termite damage. Further, a closer examination of plants just when they start withering does not reveal the presence of termites but indicates root-rot. Therefore, it is suspected that they get infested by termites at a later stage. Though such observations have been made for chillies, cotton, groundnut and wheat, it is undeniable that a closer study of the complex relationship between termite injury and infestation by pathogenic fungi is necessary ; nevertheless, there remains little doubt that the termites are more often unnecessarily incriminated than they deserve to be.

It is further known that green and healthy plants are rarely attacked by termites. But where water is scarce and the crop dries progressively or when some mechanical injury by a cultural operation results in a set-back to the growing plant, there often occurs an invasion by termites. In general, it may be stated that more often termites are incriminated for deeds which are not theirs. No doubt they help in the final destruction of the plant after the process of death has been started by some other agencies like fungi, mechanical injury, etc.

The most important problem from the agricultural point of view is the severe infestation of trunks of fruit trees and vines and the rapid destruction of freshly-planted saplings, particularly of mango and grape-vine and many ornamental trees. Feeding on the bark subsequently leads to damage of the pith and a process of slow hollowing of the stem sets in. It is common knowledge that the bark of a tree is a dead tissue which protects the layer of living tissue just beneath, the phloem, while in the centre of the stem is the pith which is also dead wood. The termities, when they feed

on tree stems, are very selective and initially attack the superficial bark. If, however, they gain entry into the pith either through the exposed stubs of cut branches or through the grafted joint, they also attack the pith. Continuous feeding on pith results in hollow stems, a well-known feature of the infested tree. It is due to this that we often see a tree which appears healthy on the outside but when cut open for timber or fuel, it is found to be hollow from within. In cultivated trees, the hollow stems often give way and the trees die. Thus, this initial superficial injury to the bark ultimately leads to the death of a tree. Besides termites, there are also certain fungi which often cause deterioration of wood.

One other aspect of losses due to termites is the rapid destruction they cause of farmyard manure. The feeding of the termites on the decaying vegetable matter contained in the farmyard manure causes considerable loss of nitrogen so valuable for plant growth, though this aspect has not been sufficiently investigated and studied. It is commonly believed, however, that farmyard manure seems to attract termites, while some other manures like castor cake lead to a decrease of termite injury. Some detailed observations are necessary in this connection. However, a survey made so far does not go to prove the latter belief, as termite injury on mango stems has been noticed even in orchards receiving castor cake manure, even though it may be less attractive to termites than farmyard manure. Hence, castor cake manure alone cannot be depended upon as a satisfactory means of safeguard.

Description : White ants belong to a group of social insects of the order Isoptera which live in nests usually made underground. They are neither white in colour nor are they ants at all and though distantly related to the true ants, they are different in structure and metamorphoses. They are whitish-yellow, flat, soft-bodied insects, with biting mouthparts and incomplete metamorphoses.

Their colonies are inhabited by two different types of individuals or castes, viz., (1) The reproductive castes and (2) The immature or sterile castes.

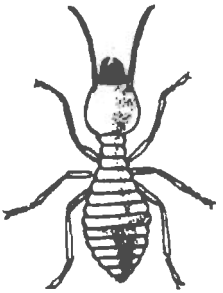


Fig. 57
A TERMITE WORKER

The reproductive castes are represented by a few kings and queens whose main function is to reproduce. This caste is initially winged and is the only caste found exposing itself to daylight. Besides, there are some supplementary mature individuals which remain underground whose function is also to reproduce but to a limited extent and in emergencies arising out of death of the queen. The queen is the central figure in the colony. The king and the queen originally have four equal wings which are used only for a single flight during their life-time, after which they are lost.

The immature castes are represented by the soldiers and the workers which are entirely wingless throughout their lives and are generally blind. They are either males or females but their reproductive organs are not functional, and hence their sex is not discernible.

The workers (Fig. 57), which generally constitute from 80 to 90 per cent. of the population of the colony, have short mandibles with which they supply food, construct the nest, feed the nymphs, the queens and the kings. This is the caste of termites that is most irksome to mankind.

The soldiers constitute about two to three per cent. of the population of the colony. There are two types of soldiers, one the mandibulate type which possesses enlarged mandibles and the other the nasuti type with a long nose-like prolongation of head but without enlarged mandibles. They both defend the colony—the former by the help of the mandibles and

sometimes by giving out a short of repellent fluid, while the latter protect the nest by plugging the holes in the nest by their heads, thus denying entry to outside predators.

Types of termites : The termites are often classified by their mode of living. Thus, there are the wood-inhabiting ones which can either live in damp wood or on dry wood, while a large number of termite species are soil-inhabiting. The latter also do damage to wood, but during their life they maintain a constant connection with the soil. The purely wood-inhabiting ones can live in wood without having any connection with the soil.

Among the soil-inhabiting types are the subterranean ones and the mound-building ones. The subterranean ones build their nests underground, while the mound-builders have part of their nests above ground, giving them the appearance of little hillocks. Some of these may even reach the height of several feet, while mounds as high as 10 to 15 feet are also sometimes met with.

Life history : Once a year, frequently during a warm-humid weather in early monsoon, the future kings and queens leave the nests of their birth and may be seen flying around dazzling street lights in large numbers. Swarming may take place even during daytime. After a short flight, their wings are broken off along definite sutures and then they pair off, mating taking place subsequently. Those which survive natural odds like dangers from predatory birds and inclement weather, pair, settles down, burrow in the soil and establish a new colony. The queen starts laying eggs at a very rapid rate in a small burrow or passage excavated by the royal couple. It is interesting to note that as many as 48,000 eggs have been found in the ovary of a single queen. Further, from the little we know about termites, it is also known that she can survive and reproduce for several years. An idea can, therefore, be had as to the rapidity with which the termites can multiply in nature. The newly-hatched nymphal termites of a new colony are fed by the royal parents. The new generation develops into workers and as egg-laying continues, these take over the work of looking after the nest.

In some pecies of termites, the queens (Fig. 58) become very much enlarged and attain a length of three to four inches. They are unable to move and are fed by workers who attend the royal chamber in which the queen constantly resides. The eggs laid are also removed by the workers to suitable places and cared for by them.

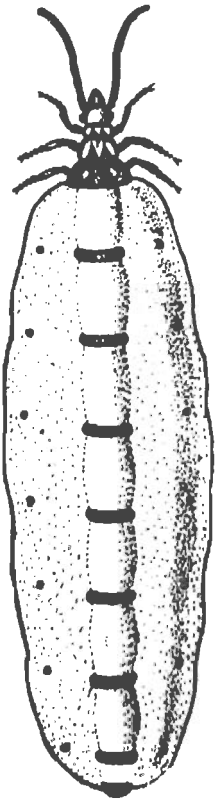


Fig. 58
TERMITE QUEEN

The termites normally feed entirely on vegetative substances, mainly wood, a material not ordinarily digested by the higher animals. They have also been found attacking paper, fungi, dried plants, partially digested food material from different animals, etc. Their ability to digest wood and

cellulose is due to the presence of certain protozoa in their digestive tracts, which help in the digestion of cellulose. Interestingly enough, these protozoa are transmitted from one individual to another as they take the anal excreta of one another. Though essentially feeding on wood, they can cultivate their other food in special fungus gardens, where they grow their own food. Certain species of fungi growing on such beds are utilized by members of the colony for their own nourishment.

The termites have a weakness for darkness and if they have to cross open spaces, they construct covered earthen runways. Such runways are commonly seen on all infested wood-work and may also form on ground surfaces and on stems of trees.

Control measures : In the Deccan and Karnatak, the problem of termite control is considerably simpler than in the Gujarat districts. In the former, the nests of termites are above ground and can be easily located. Simple destruction of the overground nest is often inadequate, since until the queen is destroyed, the nest remains viable and will again develop. The queen is not necessarily found on the overground parts and may be deep down in the soil.

Thus, mechanical destruction of the nest, if not thoroughly carried out, is unlikely to end the trouble permanently. Hence, it is found desirable to combine mechanical treatment with a chemical one. After levelling the nest, a hole 6 to 12 inches deep may be made in the centre and a fumigant like CS_2 plus chloroform mixture poured into it. Petrol can also be used though it is less efficacious. The quantity to be used will depend on the size of the nest. Generally, however if 8 to 12 ozs. are used, it will give an effective kill. For large nests which are difficult to be destroyed mechanically, cyanogas dusting by cyanogas pump through the natural openings of the nest may be tried. Methyl bromide can be also used in place of other fumigants. It can be had in glass ampoules of a convenient size and after introducing it in the nest, can be broken to release the deadly gas.

Prevention of damage to cultivated crops : In many cases, the crops are initially attacked by fungus diseases like root-rot of cotton, foot-rot of wheat, etc. In such cases, prevention of termite damage will not necessarily protect the plants, as the basic cause of damage is different. As the termites do not infest a crop which is otherwise healthy, the damage caused by them can be minimised by keeping the crop growing vigorously. Shortage of water leading to initial drying of plant may lead to termite infestation. Consequently, proper watering of crops is very essential. For prevention of damage to a cultivated crop, no sure method has yet been finalised. In case of damage to sugarcane sets, adequate protection can be obtained by dipping the sets in 0.2% DDT (water/dispersible), obtained by dipping 1 lb. of 50% DDT w/d powder in 25 gallons of water or plastering the cut end with a thick paste prepared from DDT w/d powder.

***Prevention of damage to young grafts and fruit trees*— Young grafts :** A freshly-planted graft is a delicate sapling and hence its protection from termites cells for special treatment. The main aim is to protect the graft long enough to give it sufficient time to establish itself. After transplanting, a DDT w/d spray (sold as 50% DDT w/d powder) mixed at the rate of 1 lb. in 20 gallons of water should be poured around the transplant, and the stem and the graft-joints fully wetted by this liquid. This process may be repeated every 15 days to ensure perfect protection. The second treatment may be delayed until the end of the monsoon, as the termites are not very active during the rainy season. A third treatment may be very useful if given about October or November, as the activity of the termites is very great at that time and thereafter.

Full-grown trees : For young trees the treatment given for young grafts may be followed. For older trees with stems of one foot and over in thickness, an application of 5% DDT in oil is useful. This should be applied after clearing the galleries by a brush and very thinly *just enough* to wet the lower one-and-a-half feet of the trunk near ground-level. A gallon of this material should be used for at least 80 trees;

the material is to be applied very thinly, since a heavier application will cause injury to the trees. The effect of this treatment lasts about a year. This DDT in oil solution is harmful to green parts of plants and young trees with thin stems. Hence, it should *not* be used for young grafts and small trees, as then the plants will surely get scorched. For older trees, however, when applied in the way stated above, it is not known to have caused injury.

At present many farmers use castor oil, coal tar, red earth paste 'geru' or a lime and copper sulphate paste for protecting their trees against termites. It has been found that castor oil and coal tar have some deterrent value though less than the DDT-oil mixture stated above, but both are costlier than the DDT treatment, as the consistency of castor oil and coal tar is so great that larger quantities are required for applying on stems. Red earth treatment when mixed with such a common substance as asophoetida and 'Dikamali' has no lasting deterrent value and is one of the wasteful methods of trying to protect trees. The use of castor cake as manure also cannot be relied upon fully for prevention of termite damage, but unlike farmyard manure, it does not appear to provide food for termites.

It has been observed that termite feeding is most active from October to January. Consequently, treatment may be given after the monsoon is over, so that trees will tide over the worst period safely. The aforesaid DDT-in-oil application is observed to remain effective for several months and can be relied upon to give protection for a whole year. If, however, galleries re-form on any particular tree, a second application may be given.

It may be pointed out that in an orchard not all the trees show infestation and hence if only the infested trees are treated, it will effect saving on the cost of the insecticide and labour.

Protection of wood structures in houses: The problem of protecting timber in houses is also quite important. In general, it may be stated that external application of insecti-

sides, however powerful, will not give permanent protection, unless a nearby termite colony is destroyed and structural changes are introduced to prevent their re-entry.

Though the termites are known to penetrate lime mortar, they do not enter cement slabs, unless cracks develop in them. For this reason, it is essential that for permanent protection of buildings to be built, a cement layer three to six inches thick should be spread over the plinth before the walls are erected. This cement course may be kept in level with the flooring, which should be also of cement, and all parts of wood work for doors, etc., should be clearly above this slab. The cement slab must certainly be clearly above ground level. Thus termites, which may be underground, will not be able to make their way through the cement slab and floor and then the wood structures will remain safe. Galleries of termites made outside the plinth over the slab and towards the wall can be easily detected and cleared. This periodical inspection may be undertaken so that the termites are not enabled to establish contact with wood after circumventing the cement slab. Further, the treatment slab should be continuous throughout the plinth of the house as it will not completely satisfy the purpose if it is provided only below the doors and windows, as is done in a great many cases generally.

In houses which are already infested, the method of protection is to locate the termite nest and destroy the termites and apply 5% DDT-in-oil on the infested surfaces. This will have to be repeated if the nest is not destroyed. 5% DDT-in-oil, when applied on wood work, does not penetrate deep, and hence it protects the surface but termite damage inside the wood cannot be stopped, unless the nest is located and destroyed.

Protection of fence posts : Farmers who have to erect fence posts should follow the same principle as the one described in regard to household timber. For temporary protection, coal tar or creosote oil which is commonly used can be depended upon for a time. 5% DDT-in-oil, if allowed to soak in the ends to be buried, can also give a good measure

of protection. However, no amount of insecticide or coal tar application will give perpetual protection to fence posts, unless they are separated from ground by a proper cement and sand mixture, which should be used to fix the posts. Some persons use metal tubes closed from bottom to cover the underground portion of the posts. This is, of course, costly but can be relied upon fully if no part of wood touches the ground.

Thus, proper protection can only be obtained by a certain amount of addiitonal expenditure ; but whether it is economically feasible, each farmer will have to decide for himself according to the finances available with him.

By G. A. PATEL and B. G. PATEL.

CHAPTER XIX

CONTROL OF FIELD RATS, BANDICOOTS AND OTHER WILD ANIMALS LIKE JACKALS AND PIGS

RATS

Field rats cause damage to maturing crops by cutting down and feeding on plants such as rice, jowar, wheat, sugarcane, etc. Often the groundnut crop is attacked by rats at harvest time when they excavate the pods and feed on them. Besides this direct loss, the water channels in the irrigated fields are often damaged on account of numerous rat burrows. They are also responsible for heavy losses to stored grains on farms, in godowns and in houses as well, and frequently spoil more foodstuffs than they actually eat. Even according to a very modest estimate, rats cause an annual loss of more than a million tons of food and seed-grains. However, such losses seem negligible when one considers the formidable role of these ugly creatures as carriers of the germs of the dreaded plague. With the growing need for conserving food, the necessity of devising methods of destruction of rats has acquired utmost importance.

Habits : There are several species of rats, but the most common one is 'Ratus ratus'. They are nocturnal in habits, live in burrows, in field embankments, in drains, in roofs of buildings or inside crevices of walls of old houses. The rat burrows are not very deep but are connected with one another to an enormous extent. Each burrow has three or four openings. The existence of rats can be made out by the presence of small heaps of loose soil lying near the openings of their burrows. In the godowns and houses, their activity can be surmised by the presence of irregular holes in doors and windows, bags cut at various places with loose grains lying about scattered.

In the fields, they store grains in their burrows, even upto four or five seers, and such burrows generally do not open out to the exterior. Rats are known to feed on the pulpy portions of the stems of some cereals before the earheads

develop and when the earheads are in the milky stage, they feed on the milky grains. As the crop nears maturity, they steal grains and store them safely in their burrows. In the grain godowns, they enter the stores at night, gnaw the bags and feed on the grains.

Methods of control : There are four methods of killing rats in a field : (1) hunting, (2) trapping, (3) poisoning, and fumigation.

(1) **Hunting :** It consists of engaging parties of persons who dig out rat burrows and kill the rats with the help of trained cats and dogs. In cities, with powerful water supply the flooding of burrows is also used to force them out during the day-time when they can be killed mechanically.

(2) **Trapping :** Rats can be caught by traps containing attractive food laid near their burrows. When the rats of a colony see one of their fellow-beings caught in a trap, they avoid entering them due to their strong instinct of self-preservation and thus manage to survive. Hence trapping often does not prove to be effective, except on a small scale in houses.

(3) **Poisoning :** Various poisons are used to prepare poison baits for rat control but the following chemical preparations are very effective for killing them :

(a) **Zinc phosphide :** It is a black amorphous poisonous powder which evolves phosphine (PH_3) gas when it comes in contact with moisture.

Recipe of poison baits :—

Zinc phosphide (Zn_3P_2) ...	1	oz.
Wheat flour	1	lb.
Water	suffient to moisten the bait.	

Method of preparation : Moisten the wheat flour early in the morning and keep it wet until evening. The poison is then mixed well with the flour paste and about 200 pills of equal size may be prepared for distribution in the affected

areas. Generally, two pills are kept near the mouth of each burrow in the evening.

Recipe for bandicoots :—

Zinc phosphide	... ...	1 oz.
Wheat flour	... ...	½ lb.
Water	... .	Sufficient to moisten the bait.

Prepare about 100 pills out of the above and treat the affected areas as above.

(b) **Barium carbonate :** It is a white amorphous and comparatively weak poison for the destruction of rats. It is not very useful for field use and bandicoots, but is satisfactory for use in the house.

Recipe :

Barium carbonate	...	1 lb.
Bajri flour	... ...	5 lbs.
Water	... ...	Sufficient to moisten the flour.

Method of preparation : Prepare it in the same way as the zinc phosphide recipe for poison baits.

(c) **White arsenic :**

White arsenic	... ...	1 tola.
Cooked jowar flour	...	2 lbs.
Groundnut kernal	...	½ lb.
Water	... ...	Sufficient to make a thick paste.

Method of preparation : Prepare small pills of equal size and keep two or three pills in each burrow and the latter should subsequently be closed.

(d) **Strychnine sulphate :** This is a highly toxic compound to human beings and hence should be used only when other poisons have failed. This is generally not available to the public, except in special circumstances.

Strychnine sulphate	1	oz.
Warm water	2	ozs.
Jaggery	4	lbs.
Gram	30	lbs.
Water	1	lb.

Method of preparation : Dissolve 1 oz. of the poison in 2 ozs. of warm water. Heat 4 lbs. of jaggery in 1 lb. of water to prepare a thick syrup. Then mix both the solutions thoroughly and add to this 30 lbs. of gram previously soaked for about 12 hours in water. About half an ounce of the poison bait should be put into each rat burrow, which should then be closed with mud.

(e) **Kuchla seeds (Strychnous nux vomica) :** Boil 5 ozs. of the seeds in 4 lbs. of water, crush the seeds after they are softened and continue boiling till about 4 ozs. of the extract remains. Proceed as in the case of strychnine sulphate.

(f) **Warfarin :** It is a new rodenticide available in the market. This material has met with outstanding success in the United States and is known to act slowly but surely by causing internal hæmorrhage. As it is slow-acting, the rats do not avoid the baits and pre-baiting is not essential. Ready-made baits containing 0.5% warfarin are sold in the market. The available bait is to be further diluted as 1 part in 19 parts of any meal or crushed grains before use. These baits are, however, to be eaten for three to five successive days by the rats to be effective. This rodenticide is also poisonous to the higher animals and should be used with great caution. In India, the trials of this new raticide are still to be carried out but it is likely to prove very useful. It is however experienced that repeated treatment for five days is not practicable for field use, though it may be possible for household use.

Great care should be taken in handling these poisons and in no case should they be handled by irresponsible persons. The baits should be placed in such a way that children, cattle, poultry and pets would not come by them and eat them.

TECHNIQUE OF BAITING

A survey of the infested field is essential before using the baits. During survey work, the operator should take into account the area to be treated, its rat population, the distribution of rat colonies, etc. Having surveyed the area, all burrow-openings should be closed with wet soil and the field re-examined the next day with a view to ascertaining the exact number of live burrows which can be found out by spotting out the closed burrows which have re-opened. Such observations will help economise on the quantities of poison to be used and the base as well. Rats are suspicious of anything that is new. This initial suspicion can be got over by supplying unpoisoned food known as pre-bait. Pre-bait without any poison may be given for the first two days, so as to train the rats to come to the regular feeding points. On the third evening, the poison bait may be given according to the recommended doses. On the fourth morning, the treated area may be surveyed carefully with a view to ascertaining the number of dead rats and collecting uneaten baits. The same baits may be used for a second time on the same evening and observations may be repeated as done before. And if some of the baits remain uneaten, they should be destroyed. A second round of baiting may be done at an interval of a fortnight and the treatment continued until complete control of rats is achieved.

Rats and mice have a very strong instinct to survive both as individuals and as members of a colony. If through taste or smell, they get the slightest hint that they are being poisoned, they avoid the bait as completely as they will shun a rat terrier. Hence, for a regular campaign against rats, two separate base baits and poisons are often needed. Survivors from the first effort may be prejudiced against base baits and the poisons as well. Therefore, two different poison baits may have to be used alternately to eradicate the pest.

FUMIGATION

Fumigation : Fumigation consists in treating the rat burrows with the fumes of poisonous substances known as syano-

gas "A" dust. This material is available in the form of a powder, which on contact with atmospheric moisture, liberates HCN gas which is deadly to rats and other animals.

Procedure : Survey the area, then close the burrow-openings with wet soil. Re-examine the plot next day with a view to ascertaining the exact number of burrows having live occupants inside. Then theat the opened holes with cyanogas "A" dust. The powder is applied with a foot pump (Plate VI) specially sold for the purpose. At the bottom of the foot pump is provided a glass bottle which should be half filled with cyanogas and the dust blown into the rat burrow by working the pump. Half a pound of calcium cyanide "A" dust is sufficient to treat about a hundred burrows. On an average, five to six strokes of the cyanogas foot-pump are required for each burrow. After treating the burrow, it must be closed with wet mud.

JACKALS AND PIGS

Jackals and pigs are widely distributed in all districts, usually occurring in small packs. Jackals are essentially scavangers but they can kill and eat any small animals which they can catch. Sweet cereals such as maize, and especially sugarcane, are often attacked and considerable damage may be done by gnawing the canes in the field. Besides damaging the crop, jackals act as permanent reservoirs of the rabies virus and hence they are regarded as a serious danger to society.

Control : A pound of raw flesh is got and 12 to 15 pieces are made, keeping some as reserve. A small hole is made in the centre of each piece and two grains of strychnine crystals are put in the cavity without strewing the sides. Then the cavity is closed with fresh flesh from the reserve stock. All the baits are prepared in this manner and each bait is placed separately on a piece of broad leaf like a plantain leaf. Then in the evening these baits are kept where there is a likelihood of the jackals frequenting the place. The uneaten baits should be collected the next morning and kept at a safe place to be used again the same evening. Baits once prepared

can be used for three to four days. Any surplus baits should be buried deep in the soil so that pets may not eat them.

Being a deadly poison, strychnine should always be handled with care and kept under lock and key.

This same bait can be used for pigs also.

PRECAUTIONS

(1) Care must be taken not to put the poison baits where children, domestic animals and livestock will find them.

(2) Any bait left over after poisoning operations should be destroyed.

(3) The vessels used for the preparation of baits should be washed clean after the baits are prepared.

(4) Due warning should be given to neighbouring farmers about the treatment of affected fields with poisoned baits.

By G. A. PATEL and H. V. KATKARKI.
C.P. 12A.

CHAPTER XX

DUSTERS AND SPRAYERS FOR INSECT CONTROL

For insecticidal control of insects and also for using fungicides, several appliances are available in the market. Their number, however, is so huge that not all can be discussed here. For the elementary needs of most cultivators, the following information will be sufficient.

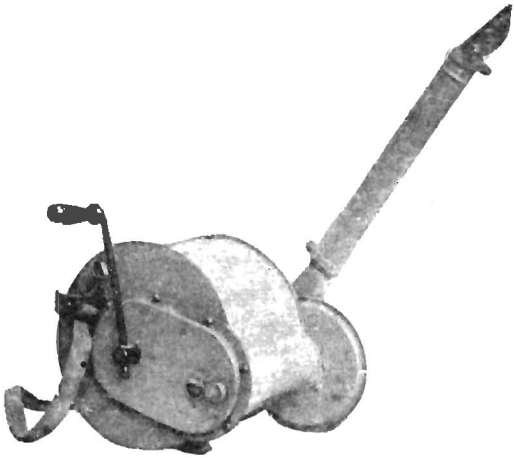
A farmer must choose appliances according to whether he wants to dust his crop or spray it. Those used for dusting are called "dusters". "Sprayers" are used for insecticides applied in the liquid form.

Dusters : These are available in various sizes. For the smallest needs such as for kitchen gardens, the farmer or gardner may use the hand-duster. The prices of hand-dusters range from Rs. 3 to Rs. 15. Such dusters can also be used in houses for bed-bugs, ants, etc. However, they are not useful for crops grown on the field scale, as such instruments will not stand the wear and tear of heavy service.

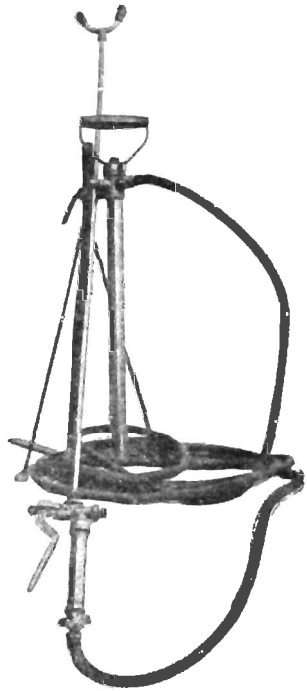
For field use, crank or rotary-type dusters are convenient for our requirements. These are available generally in two models—one in which the machine remains in front of the operator called the "chest-type" (Plate V) and the other in which it is kept on the shoulder (Plate V) called the "shoulder-type". The former is convenient for low field crops, while the latter is best suited for dusting both field crops and trees. The chest-type model is priced at about Rs. 90, while the shoulder-type costs about Rs. 100 each.

Sprayers : Sprayers are usually available in a wider range of models than dusters. The smallest sprayers are mainly useful for household purposes and for small kitchen-gardens. The prices vary from a few rupees to Rs. 50 for one of the best make. These small sprayers are not useful for field spraying and for those who have to spray field crops they should prefer either the bucket pump (Plate V), or the compression sprayer (Plate VI). The former is to be worked by keeping one end of the pump in the bucket and in good

PLATE V



"CHEST TYPE" ROTARY DUST GUN



BUCKET SPRAYER

"SHOULDER TYPE" ROTARY DUSTGUN

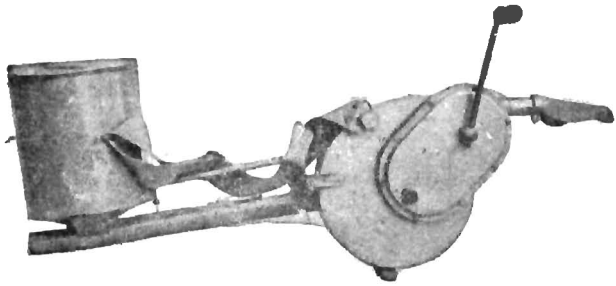
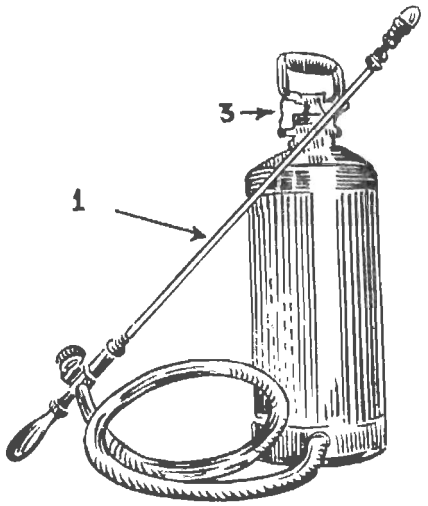
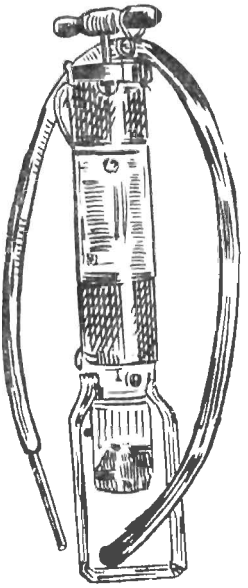


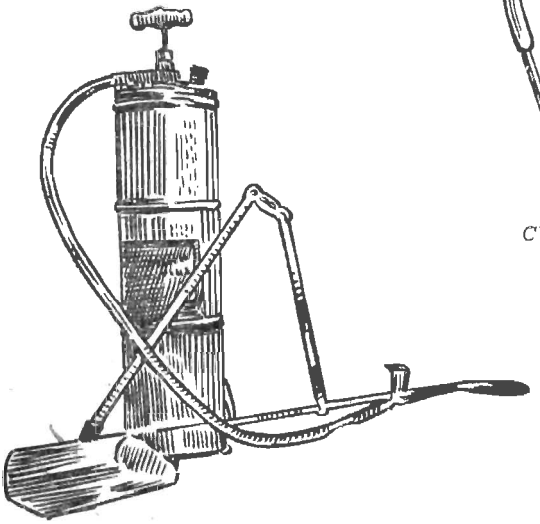
PLATE VI



COMPRESSION SPRAYER



CYANOGAS FOOT PUMP



COMPRESSION SPRAYER WITH FLAME GUN

models the discharge outlet is provided with a spray-nozzle. While working it, two men are convenient—one to pump and another to spray. An additional hand for preparing the insecticide will ensure continuity of operation. The price of a bucket pump varies greatly and it can be purchased for from Rs. 25 to to Rs. 85 each. For field work, it is essential to have a discharge hose of about 20-foot length.

Compression sprayers have a large container in which one to four gallons of spray are filled, according to its size. The air pump is worked after filling the tank three-quarters full, so as to develop air pressure inside, which pushes out the liquid through the spray nozzles worked by a shut-off. The sprayer is carried on the back while using. Spraying should be done from both the upper and lower sides in order to ensure kill of insects on both sides of leaves. A light weight, small-size compression sprayer can be carried on the back and taken up for spraying tall trees like the arecanut for which purposes it is extensively used. However, such types of sprayers are not convenient for bushy type of trees like the mango, etc., for which other types of sprayers are needed. The price of a compression sprayer varies greatly and the cost may range from Rs. 65 to Rs. 115, depending on its size, the metal used, etc.

For developing sufficient pressure required for spraying trees from the ground, two types of hand-operated sprayers are generally used in the absence of power-operated sprayers, which are definitely better but beyond the financial reach of most farmers. The pedal pumps and the rocking piston pump are so designed as to develop considerable pressure to enable spraying of moderate-size trees from the ground. Both these types should be provided with long discharge hose pipes for convenience. They are equally well-suited for field-crop spraying also. As in the case of the bucket-sprayers, if three persons are engaged for the operation—one for preparing the insecticide, another for pumping and the third for spraying —continuous spraying is made possible. The pedal pump costs about Rs. 165 to Rs. 180, while the rocking piston pump can be had for about Rs. 133 to Rs. 145.

For large-scale work, it is often convenient to use a type of sprayer called the wheel-barrow sprayer which is provided with a powerful pump and an air chamber, so that the pressure developed is sufficiently high for three-spraying and there is a continuous spray. A large barrel is provided which can be carried about on a wheel-barrow, making it a convenient instrument for constant heavy work for orchard-spraying. These are costlier appliances and are priced approximately at Rs. 300 to Rs. 500, depending on their size. Like the pedal pump and the rocking piston pump, the wheel-barrow sprayer is also convenient for field-spraying too.

By G. A. PATEL

APPENDIX I

WHAT TO DO IN CASE OF INSECT INFESTATION

Frequently, when the former faces the problems of insect infestation, he loses the battle against it just because he is unable to make up his mind as to what to do. Oftentimes philosophical as our farmer is he tends to resign himself to the evil fate brought to him by the Almighty for his or society's evils which may need a recompense. Such resignation is not entirely his fault, as unless proper educational facilities exist and unless there is an economic incentive, the desire to fight the battle against natural odds is always at a low ebb in any society. Also the fact, that there are many insect problems, the solution of which apparently seems beyond human efforts, partly contributes to this fatalistic tendency. It is therefore necessary to emphasize that in spite of many limitations in the existing methods of insect control a number of important insect pests which are dangerous to agriculture can be checked satisfactorily and there is little or no jjustification for fear of defeat and consequent apathy. In order to remove the obstacles proper guidance as to what to do in case of an insect epidemic is urgently needed.

Under the prevailing economic conditions it is not always feasible for every agriculturist to keep himself well equipped all the time for all the maladies. He has therefore to depend for advice and material on private or Government agencies. When he has to approach the Government agencies, it is advisable for the farmer first to know the exact nature of the trouble he has to face. For this purpose he should initially find out the following:

1. Is the whole plant wilting or drying up? If so, he may suspect some reasons other than insects. The sudden drying out or wilting of the entire plant may be due to fungus diseases or some physiological trouble or agronomic factors. Insects rarely if ever bring about general wilting or drying up of the *whole* plant without being detected.

2. After having satisfied himself that the basic cause of trouble may be insects, he may proceed to find out where

they are : (i) whether on the leaf, (ii) upper surface or lower surface of leaves or both, (iii) whether inside the stem or twigs, (iv) whether in roots or fruits, etc.

3. He may then be able to locate the insect proper and *along with* the damaged plant part he may show it to the nearest agricultural officer.

4. If the insect he has found on the particular crop agrees with the description of the insect in this book, then also he may get it verified to be sure. He may then get advice and act accordingly.

If it is not possible for him to go personally, he can send the insects along with the damaged plant parts in a *perforated* cigarette tin to the nearest agricultural officer or if it is sufficiently serious, he may even ask the officer to visit his field to render service.

WHAT THE GOVERNMENT CAN DO

The extension staff of the district has instructions from the Government to give all possible technical and material help to cultivators. The advice is given free but for materials like insecticides the necessary charge is to be paid if bought. If they are not available with the officer he will also indicate from where to obtain them. The extension staff has also got the sprayers and dusters which it will issue on rental basis if necessary with proper surety.

LAWS FOR PLANT PROTECTION

It is often the case that amongst many cultivators some are enthusiastic and like to control pests, but others are recalcitrant, with the result that insects may migrate from an uncontrolled field to one where they have already been destroyed by the efforts of enthusiastic farmers. This is particularly true in the case of migrating insects like locusts and army worms. Many such insect problems, therefore, become a social responsibility, necessitating co-operation from all who are affected *or are likely to be affected.* Hence for

such work co-operative efforts are not only desirable but highly essential.

In case of pests like the Deccan wingless grasshopper which visit particular localities with fairly regular frequencies, the Government has legal power to enforce measures on recalcitrant cultivators if their infested fields prove a source of danger to other farmers. For this purpose, there is an act in Maharashtra State called the Insect Pest and Disease Act under which the Government is in a position to declare certain pests as "notified" insects. Then, in such cases, the Government is empowered to take steps against those who do not treat their infested fields, thus making them a source of danger to neighbouring fields. For special needs requiring the help and co-operation of whole communities, as in the case of control of the desert locust, the Government has also armed itself with powers to effect compulsory recruitment of labour and requisition of vehicles on payment, whenever the situation demands it.

Plant protection legislation such as this has been enacted to protect the interests of all those who are keen on extending their co-operation in mitigating the scourge of insect pests. The duty of the citizen and the farmer, therefore, lies in doing their best to control pests as a matter of social obligation in order to save precious food-crops. It is, therefore, hoped that as in the past, the law will not have to be enforced as no enlightened farmer should tolerate insect invaders in his fields.

APPENDIX II

HOW MUCH INSECTICIDE IS NEEDED PER ACRE?

It is not unlikely that many farmers though keen on protecting their crop, would like to do so most economically. This fact is appreciated as it is a human instinct to economise and the Agricultural Department always decides before recommending which is the cheapest insecticide. Even then many farmers find them costly, in which case there is no relation to his economic problem. One piece of advice however may be given to all that a stitch in time saves nine. If a farmer observes his field periodically and regularly and detects the pest in its early stages he will find that the control measures work better and will prove more economical. It is therefore necessary that the farmer should examine his crop regularly and seek advice as soon as even a small damage by a few insects is observed.

After consultation with the agricultural staff, when once it is decided what insecticide is to be used the next thing is to know what quantity is required and how much he should buy.

The following are the common quantities used.

Dusting Powder

For small size crops like cumin 10-15 lbs./acre.

For medium size crop like jowar, cotton, maize 10-20 lbs./acre. For each tree of medium size 1½-2 lbs. per tree.

Wettable Powders

Small size crops will require 2½-3 lb. of 50% powder in 60-80 gallons/acre.

Medium size crops will require 3-4 lbs. of 50% powder in 80-100 gallons/acre.

In the case of a very tall crop like cane, etc., it depends on growth ; 4 to 20 lbs. 50% powder in 100 to 500 gallons/acre may be used.

For medium size trees of 20' high 2 lbs. of 50% powder in 100 gallons for 50 trees.

Wettable powder of 50% strength is usually used in the dilution of 4 lbs. in 100 gallons per acre which gives a 0.2% suspension spray.

Nicotine sulphate or pyrethrum extract is generally used @ 1 lb. in 60-80 gallons of water.

Dilutions and Quantities of Insecticides usually required

Insecticide	Dilution	Quantity required	
		For field crop	For Orchard trees
Dusts			
5 or 10% BHC or DDT or 5% DDT sulphur (1 : 1) or sulphur alone	To be used as such	15 to 20 lbs. acre	1-2 lbs./trees
Sprays			
50% DDT water dispersible powder or 50% BHC water dispersible powder or 25% DDT + 25% sulphur powder	2½ ozs. in 4 gallons of water	For small size crop 3-3¼ lbs. in 80 gallons/acre For bushy crops like cotton 4 lbs. in 100 gallons/acre	1¼ to 2½ ozs. in 2 to 4 gallons/tree
Nicotine Sulphate (40%)	1 oz. in 4 gallons of water + 3 to 4 ozs. of soap	For small size crop 1 lb. in 80 gallons + 3 to 4 lbs. soap For bushy crop like cotton 1¼ lb. in 100 gallons/acre + 4 to 5 lbs. of soap	½ to 1 oz. in 2 to 4 gallons plus 2 to 4 ozs. of soap
Rat Poison			
Zinc Phosphide	1 oz. in 1 lb. of flour with enough water to make pills	1 oz. with 1 lb. of flour will give 200 pills (use 2 pills per rat burrow)	

APPENDIX III

Some Trade Names of Insecticides

Name of Ingredient	Trade Names
5% BHC dust	Benexide 0.50, Gammexane D.025, Hexamar BHC 5%, Hexidol 805, 5% Hexyclan, Klorotex 5% BHC.
0.65% lindane (Pure gamma BHC product)	Hortex 0.65% dust
1.3% (Pure gamma BHC product)	Hortex 1.3% dust
7% BHC dust	Benexide 070, Gammexane D.027, Hexamar BHC 7%, Hexidol 807, Hexychlan 7%.
10% BHC dust	Benexide GC10, Gammexane D 120, Hexamar BHC 10%, Hexidol 810, 10% Hexyclan, Klorotex 10% BHC.
50% BHC (water dispersible)	Agrocide 50% or Gammexane 50% (DP), Benexide WP50, Hexamar BHC 50% wettable, Hexidol, 950.
20% gamma liquid concentrate	Gammelin liquid
5% DDT dust	AOI Brand 5% DDT, Guesoral 405 Hexamar 5% DDT
10% DDT dust	AOI brand 10% DDT, Guesoral 410, Hexamar 5% DDT.
50% DDT (water dispersible or wettable)	AOI Brand 50% wettable, Didimac 50% wettable, Guesoral 550, Hexamar 50% wettable
25% DDT emulsion	Didimac 25% miscible liquid
5% DDT & sulphur (1 : 1)	Guesoral 405-50, Hexamar, etc.
DDT plus BHC emulsion	Agritex (Killex), Autocide
Pyrethrum dust	Pyrodust 1000, Pyrodust 5000
Pyrethrins piperonyl butoxide	Pyrocone-E
Pyrethrum emulsion	Pyrocolloid
DDT plus BHC plus pyrethrum emulsion	FIB
Sulphur colloidal or wettable sulphur	Ultra sulphur
Nicotine sulphate 40%	Black leaf 40
Calcium cynamide dust	Cymag, cyanogas 'A' dust.
Lime sulphur wash	Fernasul
Para dicholobenzene (PDB)	PDCB
ED/CT	Killoptera, chlorosal,

Glossary of Marathi Names of Crop Pests*

Common English Name	Marathi	Scientific Name
Cereals		
Jowar		
1 Jowar stem-borer	ज्वारीचें खोडांतील कीड	*Chilo zonellus*, S
2 Army-worms	लष्करी अळ्या	*Cirphis unipuncta* (H)
3 Deccan wingless-grasshopper	बिन पंखी टोळ	*Colemania sphena-rioides*, B
4 Surface grasshopper	खरपुडी, नाकतोडे	*Chrotogonus* sp.
5 Katra hairy caterpillar	सुरवंट (कातरा)	*Amsacta* sp.
6 Jowar stem-fly	खोडमाशी	*Atherigona indica*, M
7 Flea beetles	पिसू, भुंगेरे	
8 Aphids	मावा	*Aphis maidis F.*
Bajri		
1 Blister beetle	हिंगे, बाळी	*Lytta* sp.
2 Deccan wingless grasshopper	बिनपंखी टोळ	*Colemania sphenarioides* B.
3 Surface grasshopper	खरपुडी, नाकतोडे	*Chrotogonus* sp.
4 Katra hairy caterpillar	सुरवंट (कातरा)	*Amsacta* sp.

* Compiled by Dr. G. A. Patel, Shri M. V. Kadam, H. V. Katarki & N. G. Patel with the co-operation of District Agricultural Officers and Superintendents of Research Farms & Agricultural Schools whose help is greatly appreciated.

Glossary of Marathi Names of Crop Pests

Common English Name	Marathi	Scientific Name
Maize		
1 Pink stem-borer	मक्याचे खोडांतील कीड	*Sesamia inferens* (W)
2 Army-worms	लष्करी अळया	*Cirphis unipucta* (H)
3 Deccan wingless grasshopper	बिनपंखी टोळ	*Colemania sphenarioi-des* B.
4 Banded grasshopper	खरपुडी, नाकतोडे	*Epacromia dorsalis, Thub.*
5 Katra hairy caterpillar	सुरवंट (कातरा)	*Ansacta* sp.
6 Surface grasshopper	खरपुडी	*Chrotogonus* sp.
7 Jowar stem-borer	ज्वारीचे खोडांतील कीड	*Chilo zonellus*
Wheat		
1 Wheat stem-borer	गव्हाचे खोडांतील कीड	*Sesamia inferens* W.
2 White ants	वाळवी, उधई	*Termes* sp. and others.
3 Aphids	मावा	*Aphis maidis* F.
Paddy		
1 Paddy stem-borer	भाताचे खोडांतील कीड	*Schoenobius incertellus* Wlk.
2 Swarming caterpillar	लष्करी अळया	*Spodoptrea mauritia* B.

Glossary of Marathi Names of Crop Pests

Common English Name	Marathi	Scientific Name
3 Paddy grasshopper	भातावरील टोळ	*Hieroglyphus banian* Fb.
4 Paddy blue beetle	वीट (निळे भुंगेरे)	*Leptispa pygmaea* B.
5 Paddy gall fly	पिली, (काने)	*Pachydiplosis oryzae* W.
6 Rice Hispa	करपा	*Hispa armigera.*
7 Rice earhead bug	लोंबीवरील ढेकण्या	*Leptocorisa acuta* T.
8 Rice case worm	सुरळ्यांतील अळी	*Nymphula depunctalis* G.
9 Rice Skipper	पानें गुंडाळणारी अळी	*Parnara mathias* Fb.
10 Crab	खेकडा	*Paratelphusa sp.*
Sugar Cane		
1 Sugarcane stem-borer	उसाचे खोडांतील कीड	*Chilotraea infuscatellus Sn*
2 Sugar cane top shoot borer	उसाचे शेंड्यांतील कीड	*Scirpophaga nivella* F.
3 Sugar cane grasshopper	उसावरील टोळ	*Hieroglyphus banian var-elongata.*
4 Sugar cane leaf hopper or Pyrilla	उसाचे पानावरील तुडतुडे	*Pyrilla* sp.
5 Mealy bugs	उसावरील ढेकण्या (चिकटया)	*Trionymus sacchari, Ckll.*

Glossary of Marathi Names of Crop Pests

Common English Name	Marathi	Scientific Name
6 Mealy wings or white fly	पांढरी माशी	*Aleurolobus barodensis* Mask and *Neomaskellia bergi* S.
Pest of Pulses.		
Gram		
1 Gram pod borer	घाटचांतील अळी (पापडी)	*Heliothis obsoleta* F.
Tur		
1 Tur pod caterpillar (Plume moth)	तुरीचे शेंगांतील अळी (पिसारी पतंग)	*Exelastes atomosa* W.
2 Tur Pod bug	तुरीचे शेंगांवरील ढेकण्या	*Clavigralla gibbosa* S.
3 Aphids	मावा	*Aphis medicaginis* Kle.
Peas		
1 Leaf eating caterpillar	पानें खाणारी अळी	*Laphygma exigua* Hb.
2 Pod borer	शेंगांतील अळी	*Heliothis obsoleta* F.
3 Aphis	मावा	*Macrosiphum pisi* Kalt.
Mung, Udid Chavali and Beans		
1 Aphids	मावा	—
Lucerne		
1 Leaf eating caterpillar	पानें खाणारी अळी	*Laphygma-exigua* Hb.

Glossary of Marathi Names of Crop Pests

Common English Name	Marathi	Scientific Name
Vegetable crops		
Potato		
1 Cut worms	देठ कुरतडणाऱ्या अळ्या	*Agrotis ypsilon* Rott
2 Leaf hopper	पानावरील तुडतुडे	*Empoasca-devastens*, D.
3 Potato tuber-moth	पाकोळी, बटाटे पोखरणारी अळी	*Gnorimoschema operculella* Z.
4 Epilachna Beetles	ठिपके भुंगेरे	*Epilachna* 28-*punctata* F. *E. 12—punctata*
Brinjal		
1 Brinjal shoot and fruit borer	वांग्याचे शेंड्यांतील व फळांतील अळी	*Leueinodes orbonalis*, G.
2 Brinjal leaf roller	पानें गुंडाळणारी अळी	*Eublemma olivacea* M.
3 Epilachna beetles	ठिपके भुंगेरे	*Epilachna 12-punctata* M. *E. -28-punctata*, F.
4 Jassids	तुडतुड	*Empoasca devastens*, D.
5 Aphids	मावा	*Myzus persicae* S.
Sweet Potato		
1 Sweet potato leaf eating caterpillar	रताळीचीं पानें खाणारी अळी	*Herse convolvuli* L.

Glossary of Marathi Names of Crop Pests

Common English Name	Marathi	Scientific Name
2 Sweet Potato weevil	रताळ्यांतील सोंडे भुंगेरे	*Cylas formicarius*, Fb.
Cucurbits		
1 Red and black pumpkin beetle	वेलभाज्यांवरील तांबडे व काळे भुंगेरे	*Aulacophora* Sp.
2 Fruit fly	फळमाशी	*Dacus* sp.
3 Epilachna beetle.	ठिपके भुंगेरे	*Epilachna 28-punctata*, F. *E.12-punctata* M.
4 Aphid	मावा	*Aphis malvoe* PaSc
5 Banded blister beetle	हिंगे, बाळी, सोसे	*Zonabris pustulata*, Thub
Bhendi		
1 Leaf hoppers	पानावरील तुडतुडे	*Empoasca devastens* D.
2 Spotted boll worm	भेंडीतील अळी	*Earias fabia*, F. E. *insulana* B.
3 Aphids	मावा	
Chillies		
1 Thrips	मुरडघा बोकडघा	*Anaphothrips (Scirtothrips) dorsalis* Hood.

Glossary of Marathi Names of Crop Pests

Common English Name	Marathi	Scientific Name
Onion		
1 Onion Thrips	मुरडचा, बोकडचा	*Thrips tabaci* L.
Tobacco		
1 Tobacco leaf eating caterpillar	तंबाखुची पानें खाणारी अळी	*Prodenia litura*, F.
2 Stem borer	खोडांतील अळी	*Gnorimoschemia heliopa*
3 Cut worms	देठ कुरतडणाऱ्या अळचा	*Agrotis ypsilon*, Rott.
4 Surface Grasshopper	खरपुडी, नाकतोडे	*Chrotogonus* sp.
5 White flies	पांढरी माशी	...
6 Aphids	मावा	...
Cruciferous Vegetables		
1 Mustard saw fly	काळी माशी	*Athalia proxima*, K.
2 Diamond back moth	चौकटी ठिपक्याचा पतंग	*Plutella maculipennis* C.
3 Painted bulg	रंगीत ठिपक्याचे ढेकूण	*Bagroda picta;* F.
4 Aphids	मावा	...
Oil seed Crops Safflower		
1 Aphids	मावा	...
2 Leaf eating caterpillar	पानें खाणारी अळी	*Perigoea capensis* G.

Glossary of Marathi Names of Crop Pests

Common English Name	Marathi	Scientific Name
Groundnut		
1 Aphids.	मावा	—
2 Pod sucking bug.	शेंगावरील ढेकण्या	*Aphanus sordidus*, F.
Castor		
1 Castor semilooper	उंट अळी	*Achoea janata*, L.
2 Castor capsule borer	बोंडातील अळी	*Dichocrocis punctiferalis*, G
Sesamum		
1 Gall fly	पिल्ली, काने	*Aspondylia sesami*, Felt.
2 Sphinx Caterpillar	पानें खाणारी अळी	*Acherontiastyx*, W.
3 Pod sucking bug	तीळावरील ढेकण्या	*Aphanus sordidus*, F.
Fibre Crops Cotton		
1 Spotted boll worm.	बोंड अळी	*Earias fabia*, S. *E. insulana*, B.
2 Pink boll worm.	बोंड अळी	*Platyedra gossypiella*, S.
3 Jassids.	तुडतुडे	*Empoasca devastens*, D.
4 Thrips	सुरडचा, बोकडचा	*Anaphothrips (Scirtothrips) dorsalis*, Hood.

Glossary of Marathi Names of Crop Pests

Common English Name	Marathi	Scientific Name
5 Aphids.	मावा	*Aphis gossypii*, G.
6 Cotton leaf roller	पानें गुंडाळणारी अळी	*Sylepta derogata*, Fb.
7 Red cotton bug.	तांबड्या ढेकण्या	*Dysdercus cingulatus*, Fb.
8 Dusky cotton bug	पांढुरक्या ढेकण्या	*Oxycaroenus loetus*, K.
Sann hemp		
1 Hairy caterpillars	सुरवंट	*Utetheisa pulchella*, L. *Argina cribraria*, C. *A. syringa*, C.
2 Flea beetles	पिसू भुंगेरे	*Longitarsus* sp.
3 Sann hemp stem borer	तागाचे खोडांतील कीड	*Laspeyresia* sp.
4 Sann hemp capsid bug	ढेकण्या	*Ragmus importunitas*, D.
Ambadi		
1 Jassids	तुडतुडे	*Empoasca devastens*, D.
Fruit Crops		
1 Lemon butterfly	लिंबावरील फुलपाखरूं	*Papilio demoleus*, L.
2 White flies	पांढरी माशी	*Dialeurodes* sp.

Glossary of Marathi Names of Crop Pests

Common English Name	Marathi	Scientific Name
3 Aphids	मावा	*Toxoptera aurantii*, Boy
4 Leaf miner	पानांतील अळी	*Phyllocnistis citrella*, S.
5 Fruit Sucking moth	फळांतील रस शोषणारा पतंग	*Ophideres fullonica*, L. *O. materna*, L.
6 Red ants	तांबडया मुंग्या, ओंबील	*Oecophylla smaragdina*, F
7 Mealy bugs	ढेकण्या (चिकटचा)	
8 Mites		*Paratetranychus citri.*
Mango		
1 Jassids or Mango hoppers	आंब्यावरील तुडतुडे	*Idiocerus atkinsoni*, L. *I. niveosparsus*, L. *I. clypealis*, L.
2 Mango stem borer	भिरूड	*Batocera rubus*, L.
3 Red ants	डोंगळे, तांबडे मुंगळे	*Oecophylla smaragdina*, F
4 Fruit fly	फळ माशी	*Dacus* sp.
Guava		
1 Fruit fly	फळ माशी	*Dacus* sp.
2 Bark and shoot borer	साल व शेंडा पोखरणारी अळी	*Arbela* sp.

Glossary of Marathi Names of Crop Pests

Common English Name	Marathi	Scientific Name
Pomegranate		
1 Fruit borer or Anar caterpillar	सुरसा, सुरा	*Virachola isocrates*, F.
Grape vine		
1 Grape vine flea beetle	उडद्या	*Scelodonta strigcollis*, M.
2 Thrips	सुरडघा, बोकडघा	*Rhipiphoro-thrips cru-entatus* H.
Cocoanut		
1 Rhinocerus beetle	ताडमाडावरील भुंगे	*Oryctes rhino-ceros*, L.
2 Red Palm Weevil.	ताडमाडावरील सोंडया भुंगा	*Rhychophorus ferrugineus* F.
3 Black headed caterpillar.	ताडमाडावरील अळी	*Nephantis serinopa*, M.
Stored grain Pests.		
1 Rice weevil	टोके, सोंडे	*Sitophilus oryza*, L.
2 Granary weevil	सोंडे, टोके	*Sitophilus granarius*, L.
3 Lesser grain borer		*Rhizopertha dominica* F.
4 Khapra beetle	खपरा, पोरकिडे	*Trogoderma granaria* E.
5 Rust red flour beetle		*Tribolium, castaneum*, Herbst.

Glossary of Marathi Names of Crop Pests

Common English Name	Marathi	Scientific Name
6 Saw toothed grain beetle		*Oryzaephilus surinamensis*, L.
7 Long headed flour beetle		*Laetheticus oryzae* W.
8 Flat grain beetle		*Laemopholoeus-minutus*, Oliv.
9 Angoumois grain moth		*Sitotroga, cerealella*, Oliv.
10 Fig moth		*Ephestia cautella* W.
11 Rice moth	पाखेरूं	*Corcyra cephalonica*, H.
12 Indian meal moth		*Plodia interpunctella*, H.
13 Pulse beetle	धनुर, भुंगेरे	*Bruchus chinensis* L.
Other pests		
1 Desert Locust	वाळवंटांतील टोळ	*Schistocerea gregaria* Forsk
Betelvine		
Betelvine bug	टिबा	*Disphinctus maesarum*, Kirk